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SOME PROBLEMS IN FUNDAMENTAL ASTRONOMY[1]

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IN presenting the subject of fundamental astronomy before this section it has seemed proper to consider in an elementary manner, and from an observational standpoint, some of the more important phases of the work, such as the general problem of determining positions in space, the progress of work on star places and some of the problems in the solar system.

There are possibly fifty observatories in this country where some form of astronomical observations are carried on at the present. By far the larger part of this work is in the line of astrophysics or the new astronomy. The advances in this line are remarkable. We are living in an era of creation of great reflecting telescopes. In this country alone there are eight or ten great mirrors with reflecting surfaces of from 20 to 200 square feet, now in use or under construction. Explorations into the space of the galaxies appeal to the imagination, and large sums of money are subscribed for such work. There is great interest and activity in, and remarkable increase in our knowledge through, the use of the spectroscope and photography. Our publications are full of interesting information as to what is going on in the stars and galaxies, and a different size of the universe is presented for our consideration every few years.

No such expansion is noticeable in positional astronomy. Mass production of routine observations and endless computations are prosaic and uninteresting to the uninitiated, and only exceptional men revel in celestial mechanics.

In this country fundamental observations for posi-

[1] Address of the retiring vice-president and chairman of the Section on Astronomy, American Association for the Advancement of Science, Atlantic City, N. J., December 31, 1936.

tion are continuous at one observatory only; at another photographic catalogues are being determined; at a third a general catalogue is being constructed; and a limited amount of positional work is done elsewhere. As the geometry of the universe depends basically upon positional astronomy it may be worth while for a few minutes to consider some of the processes and present needs of fundamental observations and the value of the base lines they furnish for measuring the heavens.

The way in which the size of the universe is deduced may not seem so complex, but the measurements are quite restricted in precision and complicated by many physical limitations.

Primitively we may say that the universe is measured with a foot rule. Geodesists with their standard tapes measure arcs of the earth's surface which astronomical observations show subtend certain angles at the earth's center, and from this the size of the earth is deduced. Then with two points on the earth as a base line astronomers triangulate to the planets or sun and obtain the sun's distance—the fundamental unit for all measurements of celestial distances. And finally using the sun's distance as a base line the distances of the nearer stars are found, also by triangulation. To obtain the distance of the stars the tape is multiplied a thousand million million times.

Accurate measures of distances are limited to the nearer stars. No direct measures of the distances of the great mass of stars are now possible. Precision measures furnish also positions and proper motions, and the spectroscope furnishes velocities in line of sight. There are now available positions for half a million stars; proper motions for 100,000; radial velocities for 7,000; and parallaxes for 4,000 stars.

With this precision data as a basis statistical studies furnish material for indirect or inductive methods of determining distances and motions of the stars in general. The dimensions of the universe of to-day rest largely upon these statistical methods, which give approximate rather than precise results, but which are the only methods available and are indispensable. The accuracy in such results depends upon the accuracy of the fundamental data as well as upon the statistical analysis and derived formulae.

The problem, however, is not simple; the determination of the positions and motions of the heavenly bodies is very complicated, and for a clearer understanding it is convenient to have in mind a few elementary ideas as to where the observer finds himself in space, and to realize how he must spend the larger part of his time in determining his own position and motion and the positions and motions of the coordinate planes to which the celestial objects are referred.

If now from some point, fixed in space with reference to any chosen group of stars, we should space out the stars at two different epochs we should have their directions and cross motions on the celestial sphere. The apparent direction of a star would differ from the true or real direction at any instant by the amount of cross motion in the interval of time it takes light to come from the star. Our catalogues define the directions in which we see the stars, not the true directions in which they are at that instant. Groombridge 1830 is really three minutes of arc away from the direction in which we see it. A double star may make several revolutions in the time its light is coming to us. We define the directions of the planets as they are to-day; of the stars and clusters as they were years and centuries ago; and of the spiral nebulae as they were ages in the past, when the solar system was far off in space from where it is now.

But we are not at a fixed position but are moving among the stars in our local system with the motion of translation of the solar system of some 390,000,000 miles a year. At the apex of this motion the stars are apparently separating, while at 90° from it they are drifting past us by amounts depending upon their distances. As the distances of the stars have been unknown in general, the apparent motion of the star due to the sun's motion and the real motion of the star itself have not been separable. All proper motion catalogues of to-day give the sum of these two motions. The catalogues of the future must separate them. So far the value of the solar motion has varied with each group of stars chosen for a reference system.

Not only does the sun's motion affect the proper motions, but the secular aberration due to this motion changes the direction in which we see the stars by amounts varying from zero at the apex to 13″ at 90° from it, and this affects all stars alike independent of their distances. By convention, and for convenience, this anomaly also adheres to our catalogues, which give the directions in which we see the stars rather than the directions they would have if we were not moving.

For a more complete picture of the sun's motions there should be mentioned also its motion, with the local system of stars, of 200 miles a second towards an apex among the globular clusters, or around the center of the galaxy, with corresponding aberrations of 200″ or more.

We are not only moving with the sun, however, but with the earth in its annual motion of 585,000,000 miles around the sun, giving rise to annual parallax and aberration. And here again as the distances of the stars have been unknown, catalogue positions up to the present have not been corrected for annual parallaxes, though these are small.

The most noticeable change in a star's position due to the earth's motion around the sun is the annual

aberration which may change its place by as much as 41″. This has been understood since accurate observations began, and they have been corrected for it. To know its true value at any instant it is necessary to know the direction and amount of the earth's motion at that time. This requires a knowledge of the size and shape of the orbit, such as the solar parallax, the eccentricity and perihelion, and the position of its plane, the ecliptic and the equinox, and also the constant of aberration. It is also necessary to know the directions, distances and masses of disturbing planets, in order to take into account their perturbations. The velocity of the earth varies with perturbations, with its motion around the center of gravity of the earth-moon system, and in its eccentric orbit.

It is realized, therefore, that before the true direction of a star at any time may be determined it is necessary to know the motions of the earth and other objects in the solar system.

The motion of the earth with the sun in space, and its variable motion around the sun, both enter into the determination of velocities in the line of sight, hence accurate tables of motion of the earth are necessary for all radial velocity results.

The most pronounced motion of which we are aware is the daily rotation of the earth, and this has determined another fundamental plane of reference, namely, the equator. But observations show that this plane is changing position among the stars with progressive and oscillating motions known as precession and nutation, which depend upon the shape, size and mass of the earth, moon and sun, and upon the elements of their orbits. For reduction of our observations it is necessary to determine the motions of these reference planes among the stars together with such constants as precession, nutation, obliquity and position of the equinox.

Besides the various motions of the observer with the earth as a whole of which we have been speaking, observations show small variations in periods of 12 and 14 months due to the variation of latitude or change of axis of rotation within the earth. Star places of the last century were uncorrected for this variation. It can be accurately determined only by observation, and is a continuing problem in position work.

Until recent years the rotation of the earth was believed to be uniform, and the earth has been used as a great clock to time the motions of the planets and stars. The evidence now is that this rotation varies and that astronomical time may vary as much as 70^s a century on uniform time. Nature furnishes other timekeepers, however. The most uniform time is determined for subdivisions of a day, by the oscillations of a crystal or a pendulum; for intervals of a year, by the rotation of the earth; and for parts of a century, by the revolutions of the moon and planets.

And finally our instruments are at the bottom of an ocean of air having refraction effects on rays of light traversing it, constantly varying with temperature, pressure, humidity and other changing conditions, the laws of which are not fully understood.

There is then no invariable point, line or plane in space to which we may tie the coordinates of the stars. We have therefore to set up a coordinate system with respect to the moving bodies in the solar system and determine its motion with reference to the stars. Professor E. W. Brown speaks of this as a moving frame of reference. Professor Lewis Boss considered that the problem of finding an invariable line of reference or direction in space is philosophically one of the most interesting problems which has been attempted in the whole range of science. Any system of reference planes and reduction constants becomes determinate only as the general motions in the solar system and the complex motions of the earth in particular become determinate.

The necessary and longer task of determining absolute or independent positions of the stars includes, therefore, that of determining the positions and motions of the sun and planets, the positions of the planes of reference and the fundamental constants of astronomy. As planetary motions may be determined only by reference to positions of the stars, continuous observations are required both of the planets and of the stars. The observations must be so planned and reduced as to define the coordinate planes in continuous motion among the stars and to furnish sufficient material for determining the planetary motions.

The process is one of successive approximation, first for the planetary motions, then for the star places. This is illustrated in history. The observations of Tycho Brahe in the sixteenth century permitted a solution of planetary motions by Kepler and his followers in the seventeenth century, which in turn made possible the accurate star observation results of Bradley and Bessel and their followers. From these came the tables and constants of Struve, Leverrier, Hansen and others, in the middle of the last century, forming the basis of observational work for the later part of the century, and resulting in the great fundamental catalogues of stars by Newcomb, Auwers and Boss. With these new positions of the standard stars the planetary observations of the last century were reconstructed into a great system of planetary and lunar tables and coordinated constants, by Newcomb, Hill and Brown. These new tables and constants, all marvels of analysis, have in turn made possible still more accurate star places, as exemplified by two recent

fundamental catalogues, the revisions of Auwers and Boss. These are both of great accuracy, and upon them another solution of the solar system will doubtless depend.

The observations are tedious and the reductions exacting, but the published results are milestones of progress in the unfolding of our own system, and they form a record of the sun's long journey among the stars.

Copernicus, in replacing the earth by the sun as center of the solar system, abolished the epicycle theories of Ptolemy and the ancients and demanded new theories and new orbits for the planets. Kepler and his followers lived with great anticipation as the new laws became understood. The aim of the observers 200 years ago was a new solution of planetary motions. The positions of the stars were of secondary consideration, and were used primarily for reference points. The sidereal motions as a whole received little attention. To-day the planetary motions are still of prime importance in themselves, but take on added importance in furnishing the coordinate planes and constants necessary to define accurate positions and motions in the great stellar universe revealed to modern astronomers.

Planetary and lunar theories are marvels of mathematical expression of gravitational laws. It is astonishing how complete a solution of the complicated motions in the solar system the mathematical astronomers have developed in the last 300 years, especially in view of the fact that they had remained an unsolved riddle for thousands of years. Accurate observations are less than 200 years old, yet positions of the planets are predicted within a few seconds of arc. All the larger perturbations in our system are known. New comets and asteroids, or even new planets may be expected, but their masses are feeble, giving less concern, for instance, than the uncertainty in the mass of Venus. There are still many interesting dynamical problems to be solved, and changes in theories are expected, but we look for no large deviation from theory, and certainly no dynamical upheaval such as seen in the novae. On the other hand, the streaming of the stars and the staggering dimensions and velocities of the galaxies, indicated by statistical studies, are absorbing attention, and call for expansion and increased accuracy in precision methods. The systematic errors in observed star places and motions must be distinguished from the real motions of the stars. Heretofore systematic errors in standard proper motions have amounted to 1″.0 a century in several parts of the sky, and individual motions have been uncertain by similar amounts. A considerable part of this is due to errors in early catalogues, which can not be changed, but the influence of which may be reduced as new places are added in the solutions. A few thousand motions are now known within 0″.5, and from existing data, 100,000 may be determined within 1″.0 a century. These are quantities of the same order as some of those found for galactic rotation and for group motions. There is a need, therefore, for greater accuracy in our observations both for position and for proper motion.

The older national observatories were founded by various governments mainly to promote the interests of navigation. And the needs of navigation both for the Navy and for commerce in general are still important considerations at such observatories. Observations of the sun, moon and planets and the brighter stars are required for this purpose, and as such observations form the basis of fundamental astronomy, the government observatories have become largely the fundamental observatories. And this appears necessary. The continuous observation of these objects with the necessary exacting reductions are so time-consuming and laborious that only government, or heavily endowed institutions, can assure the required continuity and permanency.

The increase of power and speed in navigation and commerce has increased the importance of the time element, and to-day an important function of such an observatory is the determination and dissemination of accurate time. This requires the most perfect clocks and clock vaults, precision instruments and accurate star places. Free pendulum clocks carry time so uniformly that they detect minute nutations in the earth's motion amounting to $^{s}.02$ every two weeks. Such clocks at the Naval Observatory are now rated by photographic observations of transits of zenith stars each 24 hours. The zenith telescope used for this purpose gives results somewhat more accurate than those from transit instruments. The time signals are sent out under control of crystal oscillator clocks. While in the past poor clock systems produced considerable errors in observations, to-day the best clocks kept under constant temperature and pressure are appreciably more accurate than the observations.

The first substantial fundamental work was done by Bradley about 1750, using a mural quadrant and a transit instrument. The work has been continued at Greenwich since that time, a mural circle replacing the quadrant in 1812, and the transit and circle combined into a transit circle in 1850. Observations were begun at Paris about 1800; a little later at Königsberg by Bessel, using a transit circle; at Pulkowa by Struve, using the transit and a vertical circle as separate instruments; and at Washington by Newcomb, using a transit circle. And there were shorter series. These men, and their successors, endeavored to establish

positions of the brighter stars with great accuracy and to accumulate material for construction of the planetary and lunar tables.

At the beginning of the last century, however, the desire for positions of more stars and of the faint stars diverted observational facilities, to a considerable extent, into mass production of less accurate positions, as illustrated by the great zone works of Lalande, Bessel, Argelander and others. And soon after the middle of the century cooperative work was started to determine fairly accurate positions of all stars to the ninth magnitude and fainter. This was begun some 70 years ago and the last southern zones are just now being observed. Twenty observatories or more have cooperated in the program. This work is now being repeated, using photographic plates, the transit circles furnishing positions of the 25,000 reference stars required for plate reduction. One half the program has been carried out this way in ten years. Additional instruments have been devoted to the plan of the astrographic catalogue for positions of all stars to the eleventh magnitude, started some years later and still far from completion. It has been impossible to carry out much of the meridian work planned for this undertaking. Thus the meridian instruments have been absorbed in mass production of only fairly accurate positions of something like a third of a million stars, and to some extent this has been with a sacrifice of fundamental observations.

The possibilities of the photographic plate furnishing positions of the fainter stars, suggested by the astrographic work, has, however, proven to be a turning point in positional astronomy. Very valuable work by Professor Schlesinger has shown that it is now possible to cover an area of 100 square degrees or more on one large plate. This reduces the number of reference stars required for photographing the sky to less than 50,000, and it reduces the task of the transit circle to one tenth that contemplated for it 50 years ago. Meridian observers welcome heartily the advent of photographic positions with the prospect that the great mass of faint star work may be cared for in this way and with the hope that more time may now be spent on fundamental work.

The recommendations of the International Astronomical Union at all its sessions have been more and more to encourage meridian work of greater precision on a well-spaced system of the brighter stars, and to carry to completion the great photographic surveys for positions of fainter stars. Dr. Kopff recently emphasized the need of series of meridian observations of absolute character and of the highest accuracy possible. He also expressed the view, emphatically, that long series of fundamental observations on the same instruments are a work of the highest value that astronomers can offer their science.

The change from the old to the new general plan for meridian work has been modifying observing programs of leading instruments for some years, and the new field is well established.

The new plan calls for a fundamental system of 2,000 or 3,000 stars to be kept under constant observation together with the sun, moon and planets.

Based upon this system, positions of some 40,000 or 50,000 standard stars, well spaced in the sky and including most of the stars brighter than the eighth magnitude, will be determined by meridian observations.

Based upon these standard stars, large photographic plates will give positions of all stars to ninth or tenth magnitude, and these in turn will furnish positions for all other photographic work.

In this way star places will become far more uniform and accurate by being based upon the same system and upon a standard system. This will do away with some of the accidental and systematic errors now attaching to zone catalogues based upon reference stars observed on individual instruments. By proper cooperation transit circles will be able to keep the standard stars under observation.

The great value of the photographic plate is in its economical and accurate differential spacing of large numbers of unknown stars among those whose positions are already known. At present photographic methods contribute little to absolute positions. The plate has neither divided circle nor uniform clock for independent spacing from pole to pole or from equinox to equinox. Meridian observers are aware of the fact that the plates must reproduce only too faithfully the systematic errors in their standard systems. Recently there is promise of using photographic plates, not for absolute spacing, but in determining the motions of minor planets relative to stars along their path. A difficulty here is to properly refer these stars to standard systems and coordinates. This is a difficulty in all differential work, where the zero points of the clock and circle or of the plate are determined from observations of reference stars only.

The fundamental catalogues which have been the standards since 1900 are now to be superseded by the Third Fundamental Catalogue of the Berliner Jahrbuch containing 1,500 stars and the new Albany General Catalogue of the Carnegie Institution with 32,000 stars. These two catalogues agree closely, and together will serve as bases of reference for positional astronomy for years to come. Inherently such catalogues are old before they appear, and these are already a third of a century old. They are most accurate at their

mean epoch, about 1900. The FK3 system is being used as a basis of photographic reobservation of all stars to the ninth magnitude, and it will be used in all national almanacs after 1939.

The fundamental catalogues have had from 1,000 to 1,500 of the historical bright stars, whose motions are now well known. In order to meet the needs of photographic work for more stars, and fainter stars, the Paris Conference, 25 years ago, increased the standard list to 3,000 by adding well-spaced stars from fifth to seventh magnitude. This was a matter of mature consideration by eminent astronomers in the conference. These stars have been well observed since that time and should be kept in the standard list. There is now another proposal to add 3,000 stars from the sixth to the ninth magnitude. Comparisons of observational catalogues with standard catalogues containing but 1,500 stars—one to each 27 square degrees—give very unsatisfactory systematic corrections. Moreover, it is very hard to get a sufficiently rigid reduction of an observational program with so few standard stars among the program stars. This has been shown by the discontinuities from zone to zone in the A. G. Catalogues and elsewhere. More fundamental stars are needed. The conclusions of the Paris Conference were that observations of the historical stars must be carried on with those of any new list. And this is still the opinion, and it is important. Dynamically the solar system is referred to them, and must continue to be. The motions of the bright stars are the best known, and they alone can be observed in the daytime—a necessity in this work.

A considerable portion of the information concerning the general structure of the universe comes from statistical studies of the fainter stars. The relation of the brighter stars to the fainter stars or of the local system to the more distant stars, clusters and nebulae is not at all well understood. The general motions in the solar system, such for example as the motion of the equinox, have been with reference to the nearer stars. If these are rotating or streaming with reference to distant objects the constants of our system may not be applicable to cosmic problems at large. And again a motion of the equinox referred to stars with large proper motions and in rotation will not represent the true dynamical precession of the earth. In the past all determinations of the precession constant have been made assuming a random motion amongst the stars used. Recent researches indicate the motion in the local system are not random, and that the local system has a high velocity as compared with more distant objects. The sun or the nearer stars may in time be found to have accelerations. Doubtless the spiral nebulae would afford a better reference system, but this would be possible only through comparison stars. Such observations, however, are now being made. The solar motion relative to the spirals is probably unappreciable with present measurements, and a true precession would result from such a solution. We can not, therefore, establish the absolute motion of the sun in space, but only its movement with respect to selected groups of stars. The growth of stellar dynamics has thus greatly enlarged the demand on fundamental observations, which now become concerned also with precision measures relating to objects in all parts of space.

With more recent instrumental methods for eliminating personal equation or care in determining it, observations are giving positions of the fainter stars quite correctly spaced as regards the bright stars. This was not realized in the past nor have corrections for it been satisfactory, the result being that the proper motions of the bright and faint stars differ, as though the bright stars were rotating or streaming on the faint background. It seems desirable for this reason also to have faint stars in the standard system in order to properly redetermine the systematic corrections to old catalogues and thus determine better motions for faint stars in large numbers. Such standard stars should be selected by magnitude, type and small proper motion so as to represent a distant and stable system.

The practical astronomer must spend considerable time in care, improvement and investigation of his instruments, notwithstanding that they are among the most highly developed instruments in the world.

The transit instrument and a vertical circle, used separately or combined into a transit circle, are the standard instruments for fundamental observations, though other types of instruments are being tried. The errors of all divisions on the graduated circles are carefully measured, and the irregularities in the pivots and micrometer screws are investigated. The spider webs used to follow a star across the meridian in the instruments at the Naval Observatory are driven by tiny synchronous motors built into the micrometers. This, together with the use of reversing prisms and screens, eliminates a very large part of the personal equation of the observers, and that remaining is determined from moving artificial images.

Twelve-hour circumpolar observations define the pole point of the instrumental meridian independent of star place, and stable meridian marks are used for determining very accurately the variation of azimuth.

In all absolute declination work the pole point of the graduated circle is determined from circumpolar observations. While with adopted flexures and refraction two standard instruments agree closely at the pole, they sometimes differ as much as 2″ in going 90° from the pole. This is attributed largely to flexure, the determination of which has always been unsatisfac-

tory. Some instruments are provided for interchange of object glass and eye end, but observations show that in most cases such interchange fails to eliminate the flexure. Reflection observations have never been conclusive as to flexure. New instruments show no improvement over old ones as to this error.

The best determinations of refraction are possible for observatories at high latitude such as Pulkowa, where stars south of the zenith may be observed also below pole. The Pulkowa refraction tables are now generally used and require little correction. The small deviations from them given by solutions of circumpolar observations represent mostly local conditions such as refraction around or in the building, location of thermometers, and daily and annual variations in such conditions. Such a solution represents the best value for reduction of work on the instrument used and possibly need not apply to other instruments with different local conditions. Modern buildings are constructed to allow free circulation of air and a wide exposure of the instruments to the open sky. Comparisons of observations in northern and southern hemispheres furnish additional information as to refraction, especially that towards the equator. In some locations the refraction seems to be different north and south of the zenith. Refraction solutions are frequently unsatisfactory, and both flexure and refraction require a careful investigation for each instrument.

For many instruments the pole point is the only zero point of the circle determined independently. Where the sun and planets are observed, however, a much stronger method of reducing declinations is possible, in that an additional point 90° from the pole and on the opposite side of the zenith is available. This principle was used by Newcomb in establishing his equatorial declinations, and these have held good for 70 years. It has been used in the new catalogue by Dr. Kopff, who expresses the opinion that Newcomb's method of using the sun and planets seems to be the best way of finding the errors of an instrumental system in declination at present. The determinations of the position of the equator and equinox are now made to depend upon day observations of the sun and inner planets, and also upon night observations of the moon and outer planets which are observed under the same conditions as the surrounding stars. The asteroids may also be used for this purpose. The differences between the day and night observations are determined from observations of bright stars, both day and night. Declination observations with different instruments reduced with solutions for both the pole and the equator agree within 0″.25 throughout the meridian.

For elimination of periodic errors and day terms observations extend over 12 to 24 hours each day, and include observations of the sun, Mercury and Venus, and bright stars during the day; observations of clock and azimuth stars, evening and morning 12 hours apart; and observations of the moon, planets and standard stars throughout the night.

It requires five to ten years to observe a catalogue of stars, and several years more to complete the reductions. The planetary observations continue with each catalogue. The final reductions of such work furnish corrections to the tabular positions of the planets and stars adopted for comparison, and corrections to reduction constants. From the circumpolar observations values of the constants of aberration and nutation may be determined. Newcomb's values of these constants are closely upheld by modern observations. Investigations of results from recent sun and planet observations uphold also Newcomb's position of the equator among the stars and his motion of the equinox. The right ascensions of his standard stars, however, must be decreased by $^{s}.04$ or $^{s}.05$ to satisfy observations with traveling threads.

The comparisons of such independent catalogues of stars taken at widely different epochs furnish the proper motions of the stars, and the combination of such catalogues forms a fundamental catalogue. In the recent fundamental catalogue FK3 the system has been based on the more accurate independent observations since 1845, and Newcomb's value of the precession is used. There are now possibly 3,000 stars whose positions are known within 0″.1, and, with application of systematic corrections, 300,000 within 0″.4 or 0″.5.

There is, however, a need for observations with smaller systematic errors. For this it is necessary to have more information as to day terms and refraction effects; better determinations of and greater elimination of personal and instrumental errors; improvements in instrumental equipment; and rigid observing programs. Work in astrophysical lines and with large reflectors, with its speedy output and interesting results, is very tempting. The tendency in this direction at fundamental observatories should, however, not be allowed to interfere with their already limited programs of fundamental work. The problems of astronomy are now so diverse and complex that the greatest success may be attained by concentrating the energies of each institution upon its major program and its supporting activities.

One half the observations used by Newcomb in his tables of the inner planets were made at two observatories only—Greenwich and Paris—and these show marked systematic differences. There are instances also where longitudes of the sun from two different instruments differ a second of arc for a number of years at a time—a quantity the size of fluctuation. There are small discordances between occultation and meridian observations of the moon. Much of the dif-

ference between theory and observation in the longitude of the moon is attributed to fluctuation in the earth's rotation. This follows no formula, and it can be determined only by continuous and uniform observation. Dr. Ross found a lack of observational material for his work on Mars. He also called attention to large systematic differences between mean results from different instruments, and expressed the opinion that more accurate positions than are now available are necessary for proper determination of fluctuation. Positions of the equator and the equinox from different series may differ a third of a second of arc.

Continuous observations of this nature are now being carried on at three observatories, Greenwich, Washington and the Cape, with shorter series at Pulkowa and elsewhere. There is clearly a need for another such series. For this the instrument should be in the southern hemisphere, south of 40° south latitude, so as to permit a satisfactory solution for the pole. To insure continuity and permanency it should be under government supervision. I believe it would be of great help to observational astronomy of to-day, and of lasting benefit to astronomy in the future, to establish another series of continuous observations of the sun, moon and planets and standard stars in the southern hemisphere.

And finally a word may be said as to future reductions and theory. The new fundamental catalogues will require new systematic corrections to all the 600 catalogues of the past, with corresponding changes, averaging 0".2 or 0".3, in all centennial proper motions. Present programs are furnishing large amounts of material for determination of proper motions, and these will need to be discussed for general motions in space and for a new value of the precession constant. Theoretically, Newtonian dynamics define precession, but the constants of the earth-moon-sun system entering into it are not sufficiently determined to give a complete solution. In fact, the best value of the ellipticity of the figure of the earth is determined from the observed precession. The precession is therefore determined by combination of theory and observation. The best determinations at present are based on the observed motions of some 6,000 of the brighter stars, but better material, and a much larger amount, will soon be available for discussion of this important constant. It is complicated by the motions of the comparison stars, including a possible galactic rotation of 1", and by dynamical relations in the solar system, including also a relativity effect of 2".

The present planetary and lunar tables are very accurate, and with minor corrections will be sufficient for a long time. They depend largely upon observations in the last century during which astronomical time gained continuously on uniform time. Planetary motions should represent uniform time if it is found possible to define such time. The knowledge of the geophysics of the earth is so limited that tidal retardation can not be accurately computed, nor can fluctuation be predicted. The fluctuations in the longitudes of the sun and moon are not well correlated. Observations in declination as well as in right ascension should be discussed for the longitudes. The difference between theory and observation of the moon is now 16". The correlated residual for Mercury is 6", but observations give 3". There is a similar discrepancy about the year 1785.

Planetary tables include sufficient terms in adopted theoretical expansions to give tabular positions within 1". Single observed positions approximate this, and normal positions are considerably more accurate. It may be possible, therefore, now to determine more exact coefficients in the expansions and to include higher terms. Residuals of 5" in the longitude of Neptune, which has been observed but part way around its orbit, may be satisfied by simple changes in its elements. There are residuals in longitude for several of the other planets. Pluto suggests expansion in planetary theories, and the asteroids and satellites constantly furnish new and interesting problems. The mass of Mercury is uncertain, and the meridian observations of this planet need further discussion. The secular motion of the perihelion given by observation is uncertain by a number of seconds, the transits and the meridian results being discordant. The theoretical motion has been computed five times with a range of 3", using the same masses of the disturbing planets. The mass of Venus is uncertain by one part in a hundred, and this leads to uncertainties in the periodic and secular terms in other planets depending upon this mass, such as the secular variation in the obliquity for which discordant results are obtained, and an uncertainty of 3" in the motion of Mercury's perihelion. There are rather large residuals in the observations of Mercury and Venus near inferior conjunction.

The observations of the moon need to be corrected for irregularities of the limbs, and the residuals in latitude and longitude require further study.

There is some question as to the value of the aberration deduced from latitude work. The visual and photographic zenith results give discordant values of this constant, but very accurate values of the constant of nutation. To avoid confusion it would seem best not to change the fundamental constants now in use, except the equinox, until a complete new adjustment can be made. These problems have been suggested by

the observations, and there are many others awaiting investigation.

Some 40,000 observations of the sun, moon and planets have accumulated in the 40 years since the construction of the present tables. This great mass of observational material has nearly as much weight as that used in the tables. It is as yet largely undiscussed. There are also some older series needing rediscussion.

Modern calculating machines are becoming very valuable for carrying out the long numerical operations required in such computations, and with a minimum of labor and a maximum of efficiency.

Contributions to astronomy from endowment funds have been generous. The great Albany catalogue, just being completed by the Carnegie Institution of Washington, will be of great value to astronomers. The results from Mt. Wilson are inestimable. Many important investigations have been made possible by grants from various research funds, and much more support is desirable.

The present generation has had many men of outstanding ability in this work who are passing on a heritage to the younger men of to-day. It is an open and inviting field for investigation. In our classrooms and observatories there may be young men with special talent for such work. I know of no greater help to astronomy nor of any more profitable use of endowment funds than that those who are directing larger astronomical activities should make provision for men of marked ability to study with theoretical men and at fundamental observatories, and later, furnished with assistants and facilities, to make a complete discussion of all observations into a new and comprehensive solution of planetary motions.

I leave with you the suggestion that a more complete solution of the motions in the solar system is now an important problem in fundamental astronomy.

OBITUARY

JESSE EARL HYDE

JESSE EARL HYDE, professor of geology at Western Reserve University, Cleveland, Ohio, died on July 3, 1936. He was born on May 2, 1884, in Rushville, Ohio, the son of Eber and Flora (Johnson) Hyde. He passed his boyhood in Lancaster and attended Ohio State University, graduating in 1906. He held minor positions in Harvard and Columbia Universities and became assistant professor of geology in Queen's University, Kingston, Canada, in 1911. From this position he was called to Western Reserve University as associate professor in 1915, becoming professor after the death of Professor Cushing in 1921.

The father of Professor Hyde was a pharmacist by profession and a geologist by avocation. There was built an annex to the family home, a room devoted to collections and work in geology, and in this room Jesse spent most of his boyhood leisure. During those years and later there were collected thousands of specimens, and these are now in the possession of Western Reserve University.

A discussion of Hyde's work and influence during his Cleveland years falls somewhat naturally into certain categories. The first to be discussed is his interest as a teacher, one might say also, as a conversationalist. In all his personal contacts he promptly struck a responsive strain, and when he spoke, no one, in his class or outside, failed to give him attention. Probably his most stimulating teaching was in the course called "Evolution of the Earth and the Ascent of Man." These class lectures were so inspiring that a number of his colleagues joined themselves to his listeners. His fund of experience, his philosophical interpretations and his manner of approach were such that his auditors received a stimulus which was high above the ordinary classroom type.

In 1922 Professor Hyde became formally associated with the Cleveland Museum of Natural History, then in its early stages. He was curator of geology until his health in 1931 required the severance of the more formal connection. However, he continued in the capacity of adviser and volunteer curator after that date. The work of those years was three-fold. He left the entire geological collection completely labelled, catalogued and arranged as a study collection. He directed the collection of fossil fishes, and the Cleveland Museum now possesses the best collection in existence of Devonian fish in the Cleveland shales. He was justly proud of the J. H. Wade gem collection which he arranged, a laborious and rewarding piece of work. It has been called the best exhibited gem collection in America.

He worked many summers under the Ohio State Geological Survey. His work on the Waverly Formation is of considerable magnitude, but has not yet been published. The "Camp Sherman Quadrangle" (Geological Survey of Ohio) is a monograph of 185 pages. About fifteen other publications are of lesser size. He was on the Geological Society of America Exchange Committee, in charge of the exchange, distribution and deposition of geological publications from all over the world.

Professor Hyde often deplored the sacrifices he made in attending committee meetings in the adminis-

tration of his democratic university. He was called upon incessantly and was a most patient and useful counselor. It is only natural to assume that his misgivings in devoting so much time to this type of work were assuaged by his feeling that he was helpful, and he surely had some interest in this type of intellectual activity. His sense of duty was no doubt an important factor.

To an outside observer Professor Hyde's academic career may have seemed of about the same nature of that of the usual college professor, more successful in some respects, less so perhaps in others. Only a few were familiar with a less apparent versatility which when fully realized marked him as unusual. There was in him a strain of the artistic and an even more striking strain of the philosophical. In the former connection he was especially interested in the use of lines. He studied intensively available types of drawings and etchings, partly from an inherent interest, partly to enable him to produce with the desired degree of satisfaction the graphic representations of his work. The drawings in his work on the Waverly Formation illustrate his success in such portrayals.

To a few he directly revealed his philosophical bent. Others appreciated this from his lectures and his conversation. Practical results of this bent are seen in some of his informal essays, in his annotations in his books, his lectures, the conferences he held with students in discussing their religious problems. However his intense devotion to these fields of thought, revealed more clearly after his death, comes as a surprise to some even who knew him well.

Especially noteworthy among his interests was book collecting. One lot, collected no doubt with a sense of humor, he called his "monkey books," a lot of specious undisciplined writings aimed at evolution. A serious and larger collection includes books which he used to clarify his ideas not on what one might call "Conflict of Science and Theology," but rather on the consonance of scientific and spiritual interests. His most valuable collection is an outstanding set of biographies and autobiographies of scientists and naturalists.

HIPPOLYTE GRUENER

RECENT DEATHS AND MEMORIALS

PROFESSOR STANLEY ROSSITER BENEDICT, for many years head of the department of biochemistry at Cornell University Medical College, died suddenly on December 21. He was fifty-two years old.

DR. MARSHALL AVERY HOWE, director of the New York Botanical Garden, died on December 24 at the age of sixty-nine years.

WILLIAM CAMPBELL, professor of metallurgy at Columbia University, died suddenly on December 16 at the age of sixty years.

DR. J. K. FOTHERINGHAM, reader in ancient astronomy and chronology in the University of Oxford and honorary assistant in the University Observatory since 1925, died at Dumbarrow on December 12 at the age of sixty-two years.

JOHN NICHOLAS VROOMAN VEDDER, professor of thermodynamics at Union College, Schenectady, N. Y., died on December 26. He was sixty-three years old.

A PORTRAIT of the late Charles Proteus Steinmetz, of the General Electric Company, was unveiled on December 14 in the assembly hall of the Steinmetz High School, Chicago. The portrait is the gift of the General Electric Company. It was accepted on behalf of the school by Mayor Kelly and by Principal D. F. O'Hearn.

ACCORDING to a wireless dispatch to *The New York Times,* the twenty-fifth anniversary of Roald Amundsen's discovery of the South Pole was marked on December 14 by a meeting in the polar museum aboard Dr. Fridtjof Nansen's vessel *Fram,* in which tablets were unveiled in memory of Nansen and Captain Otto Sverdrup by Knud Ringnes, chairman of the *Fram* committee, and in memory of Amundsen by Knut Doaaas.

SCIENTIFIC EVENTS

THE BRITISH COMMONWEALTH SCIENTIFIC CONFERENCE

THE British Commonwealth Scientific Conference met recently in London, under the chairmanship of Sir Charles Howell Thomas. The London *Times* reports that the commonwealth delegates were impressed by the effectiveness of the system administered by the executive council of the Imperial Agricultural Bureaux and favored the continuance and the extension of this system.

In his address Sir Charles pointed out that after having been on trial for seven years this cooperative commonwealth scheme may be said to be firmly established on a permanent basis, and that it shows "two main factors which underlie successful inter-imperial scientific cooperation. One is that the objective must be clearly defined, strictly limited in scope and of a nature which appeals to all units of the commonwealth. The second is that the executive body must owe allegiance to no particular government, but be strictly rep-

resentative of all and constituted on a basis of complete equality. Clearly in such a case every decision taken must be unanimous; there can be no question of voting, for no scheme could proceed with any prospect of success if there were even one dissentient."

He continued:

The present work of the Imperial Agricultural Bureaux aims at keeping research workers in close touch with all that is going on throughout the world in their respective fields of science. The course of scientific work in the sciences related to agriculture is proceeding so rapidly that such an information service is essential. The service incidentally is available on payment to workers outside the Empire.

The information side of the council's work is financed strictly on the principle laid down by the Imperial Committee on Economic Cooperation and Consultation. The executive council has other duties in which Commonwealth Governments are interested. One in particular affords an example of a scientific activity in which all Commonwealth Governments are either actually or potentially interested, and which is therefore peculiarly suitable for inter-Imperial treatment. This is the parasite laboratory established at Farnham Royal, Slough, to study and distribute throughout the Empire the insect parasites which attack injurious insects and noxious weeds. Certain Dominions are making more use than others of its services at the moment, but all realize the potential value of the work. Hence all are concerned to preserve intact the basic staff, while the individual requests for help can be dealt with on the basis of payment for services rendered.

To a less extent the same principle applies in the case of the Institutes of Entomology and Mycology, dealing respectively with insects and fungi. Their work is partly information in providing plant pathologists throughout the Empire with summarized accounts of the progress of scientific development, and partly the identification of specimens submitted. The extent to which the various Dominions and Colonies benefit from this service determines the contributions made towards its maintenance. Finally, the executive council provides an avenue through which certain Dominions may contribute to research projects in which they are specially interested, such as wool research at Torridon, Leeds, and low temperature storage and transport research at Cambridge and the Ditton laboratory.

NEW ADDITION TO VANDERBILT UNIVERSITY HOSPITAL AND MEDICAL SCHOOL

THE new addition to the Hospital and Medical School of Vanderbilt University, which is now under construction and will be completed by the autumn of 1937, will provide an increase of about 1,500,000 cubic feet to the present medical building. This is expected to add greatly to the efficiency and range of service in the University Hospital. Facilities of the Medical School will be increased also and better adapted to the needs of medical education. This development has been made possible by the donation of $2,500,000 from the General Education Board of the Rockefeller Foundation. Of this amount about $950,000 will be expended on the equipment and building.

This gift affords facilities for improving the teaching, especially in obstetrics and gynecology and pediatrics. An increased number of beds will be provided and the laboratory facilities will likewise be increased for research.

There will be 155 additional beds in the new addition, which will mean, including those in the present building, a total number of about 375 beds. Of this number as many as 90 beds will be used for private and semi-private patients. There will be about 40 beds for teaching pediatrics and 30 beds for clinical instruction in obstetrics. A ward will be provided also for gynecology, including 18 beds.

The Out-patient Service will be enlarged so as to provide special quarters for obstetrics and gynecology and pediatrics. The Department of Radiology will be moved to the second floor level in the south end of the new addition. This will afford increased space and better equipment for this service. The Department of Preventive Medicine and Public Health will be moved into the north wing of the new addition, and the rooms now occupied by this department will, in large measure, be used for the extension of the stock room of the Medical Library. This will make it possible to enlarge the reading room of the library.

THE ASIATIC PRIMATE EXPEDITION

INVESTIGATORS from Harvard University, Bard College and the Johns Hopkins University, according to an announcement in *The Harvard Alumni Bulletin*, left at the end of December for Siam, Borneo and Sumatra in order to study the Asiatic anthropoid apes, especially the gibbon, in their native forests. Others will start in January.

Harold J. Coolidge, Jr., assistant curator of mammals at the Harvard Museum of Comparative Zoology, who has made many studies of anthropoid apes, leads the group. The other members are: Dr. Adolph H. Schultz, associate professor of physical anthropology at the Johns Hopkins School of Medicine, primate morphologist; Dr. C. R. Carpenter, lecturer in psychology at Bard College, who has made studies of the social life of monkeys in Central America; Sherwood L. Washburn, who holds a Sheldon traveling fellowship in anthropology; John A. Griswold, Jr., research assistant in the Harvard Museum of Comparative Zoology; Andrew Wylie, of Washington, D. C., special assistant for the collecting of large mammals, and John T. Coolidge, Jr., of Milton, Mass., artist and photographer.

Some members of the expedition sailed from New

York for Singapore on December 29 on the *Kota Tjandi;* the others will go from Vancouver on the *Empress of Japan* on January 9. The two groups will connect at Singapore and proceed thence by rail, by way of Bangkok, to Chiengmai in northern Siam, where a camp will be established from which Dr. Carpenter will study for three or four months the social life of the gibbon.

Early in May, the whole expedition, except Dr. Carpenter, will go to British North Borneo. One group, using Jesselton as a base, will make collections on the higher slopes of Mt. Kinabalu, and the other, using Sandaken as a base of supplies, will make studies and collections in the lowland forest on the east coast of the island. The North Borneo investigation will terminate in August so that certain members of the expedition may return to the United States in time to resume their college work in the autumn.

In July, when the rainy season begins in northern Siam, Dr. Carpenter will move his camp to the mountains of northern Sumatra, where Harold J. Coolidge will later join him; they will make studies of the orang-utan. At the conclusion of the work in north Borneo, Mr. Coolidge will spend a month in Java and another in Sumatra making a survey of wild life; that study is sponsored by the American Committee for International Wild Life Protection and will be supported by a special grant from the Bureau of International Research of Harvard University and Radcliffe College.

The project as a whole will be known as the Asiatic Primate Expedition. It will be financed by the Carnegie Institution, the Columbia University Council for Research in the Social Sciences, the Milton Fund at Harvard, and also by private donations.

THE SECOND INTERNATIONAL TESTING CONGRESS

AT its first congress, held in Zurich in September, 1931, the International Association for Testing Materials has, according to the *Bulletin* of the American Society for Testing Materials, accepted an invitation from the committee representing British members to hold the next congress in Great Britain, and recently the permanent international committee approved the suggestion that the congress be held in London from April 19 to 24, 1937.

The object of the congresses held by the International Association for Testing Materials is to obtain international cooperation in the study of materials and their testing and to provide facilities for the exchange of views, experience and knowledge with regard to all matters connected with this subject.

The proceedings will be based on selected papers, which, by invitation, have been contributed by leading authorities in their respective fields throughout the world. Most of these invitations have been issued, and approximately 150 papers have been promised. Some twenty-two papers to be presented at the congress will be prepared by American authors. Matters in connection with American participation are being directed by W. H. Fulweiler, representative on the permanent committee. The organization of the congress has been undertaken by a congress organizing and reception committee, which consists of the British committee and representatives of many leading British institutions.

The subjects selected for discussion are divided into four groups dealing respectively with metals, inorganic materials, organic materials and subjects of general importance. The following subdivisions have been made:

Group A—Metals: (1) Behavior of metals (mechanical and chemical) as dependent upon temperature, particularly in regard to high temperatures; (2) progress of metallography; (3) light metals and their alloys; (4) wear and machinability.

Group B—Inorganic Materials: (1) Concrete and reinforced concrete; (2) erosion and corrosion of natural and artificial stone; (3) methods of testing ceramic bodies.

Group C—Organic Materials: (1) Textiles; (2) wood cellulose; (3) timber preservation; (4) aging of organic materials; (5) colors and varnishes.

Group D—Subjects of General Importance: (1) Relation between the results of laboratory tests and behavior in use and service; (2) the bearing of recent advances in physics and chemistry on the knowledge of materials; (3) the properties of materials for the thermal and acoustic insulation of buildings.

A Congress Book will be issued, which will contain, in addition to the papers presented, an account of the proceedings, articles by each of the four group presidents, in which attention will be directed to the principal additions to knowledge recorded in the papers and discussions. The papers as presented will generally not exceed 1,000 words each in length. They will be printed in English, French or German, in which languages the proceedings of the congress will be mainly conducted.

In addition to the technical sessions of the congress numerous visits to places of scientific and industrial interest will be arranged, as well as excursions and social functions, including a banquet, a dance and official receptions.

Detailed information will be issued in due course. All requests for further information and inquiries should be addressed to the Honorary Secretary of the Congress, Mr. K. Headlam-Morley, at the offices of the British International Association for Testing Materials Committee, 28 Victoria St., London, S. W. 1. Sir Frank Smith, secretary of the Royal Society of Great

Britain and secretary of the Department of Scientific and Industrial Research, is chairman of the executive committee on the congress organizing committee, and Dr. H. J. Gough, superintendent, Engineering Department, National Physical Laboratory, is chairman of the British International Association for Testing Materials committee.

A NEW SOIL SCIENCE SOCIETY

AT a joint meeting of the Soils Section of the American Society of Agronomy and of the American Soil Survey Association in Washington, D. C., in late November, these organizations voted to merge and form the Soil Science Society of America. The object of the new society is to foster all phases of soil science. Sections have been organized in soil physics, soil chemistry, soil microbiology, soil fertility, soil morphology, classification and cartography and soil technology. A close affiliation with the American Society of Agronomy will be maintained. The papers presented at the annual meeting will be published in a volume of *Proceedings*. This volume will supersede the annual *Bulletin* of the American Soil Survey Association. The society elected the following officers:

President, Richard Bradfield, the Ohio State University, Columbus, Ohio.

Secretary and Vice-President, A. M. O'Neal, Sugar Cane Soil Laboratory, Houma, La.

Secretary-Treasurer, P. E. Brown, Department of Soils, Iowa State College, Ames, Iowa.

Chairmen of the various Sections:

I. Soil Physics, H. E. Middleton, Division of Research, Soil Conservation Service, Washington, D. C.

II. Soil Chemistry, S. F. Thornton, Purdue Agriculture Experiment Station, Lafayette, Ind.

III. Soil Microbiology, L. M. Turk, Department of Soils, Michigan State College, East Lansing.

IV. Soil Fertility, W. H. Pierre, Department of Agronomy, West Virginia Agricultural Experiment Station, Morgantown.

V. Soil Morphology, Classification and Cartography, L. C. Wheeting, Department of Agronomy, Washington State College, Pullman, Wash.

VI. Soil Technology, L. R. Schoenmann, Department of Land Use, University of Michigan.

SCIENTIFIC NOTES AND NEWS

AS has already been announced in SCIENCE, the annual meeting of the British Association will be held next year in Nottingham from September 1 to 8, under the presidency of Sir Edward Poulton. Presidents of the sections have been elected as follows: Section A (Mathematical and Physical Sciences), Dr. G. W. C. Kaye; B (Chemistry), Dr. F. L. Pyman; C (Geology), Professor L. J. Wills; D (Zoology), Professor F. A. E. Crew; E (Geography), Professor C. B. Fawcett; F (Economics), Professor P. Sargant Florence; G (Engineering), Sir Alexander Gibb; H (Anthropology), Dr. J. H. Hutton; I (Physiology), Dr. E. P. Poulton; J (Psychology), Dr. Mary Collins; K (Botany), Professor E. J. Salisbury; L (Education), H. G. Wells; M (Agriculture), J. M. Caie.

THE Penrose Medal of the Geological Society of America for 1936 was presented on December 30 to Dr. Arthur Philemon Coleman, professor of geology emeritus at the University of Toronto. The award is made "in recognition of eminent research in pure geology and of outstanding original contributions of achievements which mark a decided advance in the science of geology."

DR. RICHARD E. SHOPE, of the department of animal and plant pathology of the Rockefeller Institute for Medical Research at Princeton, N. J., has been awarded the John Phillips Memorial Medal for the year 1937 by the American College of Physicians.

THE New York Academy of Sciences has awarded the A. Cressy Morrison prize of $250 to Dr. Albert F. Blakeslee, A. Dorothy Bergner and Amos G. Avery, of the department of genetics, Carnegie Institution of Washington, Cold Spring Harbor, L. I., for their paper on "The Geographical Distribution of Chromosomal Prime Types of the Jimson Weed." The second prize of $150 has been awarded to Dr. Frederick Fey Sheldon, of the University of California, for his paper on "The Bones, Muscles and Probable Evolution of the Catfish and Related Species."

THE American Institute, New York City, has made the following awards: A fellowship to Watson Davis, director of Science Service, for "interpreting to the people of the nation the rapid progress of science upon which modern civilization depends and for the organized dissemination of research findings as news"; a gold medal to the Bell Telephone Laboratories for "researches in electrical science which, applied to communication, have promoted understanding, security and commerce among people by transmitting human thought instantly throughout the world."

AT the one hundred and eighteenth annual meeting of the New York Academy of Sciences, Dr. George H. Sherwood, educational director of the American Museum of Natural History, was reelected honorary president. Honorary members were elected as follows: Professor K. S. Lashley, of Harvard University; Pro-

fessor Henri Breuil, of the College of France; Dr. Julian S. Huxley, of the Zoological Park, London; Dr. Aleš Hrdlička, of the U. S. National Museum; Dr. Alfred Cort Haddon, of Christ's College, University of Cambridge; Sir Arthur William Hill, director of the Royal Botanic Gardens, Kew, and Professors Maurice Caullery and Octave Duboscq, of the Sorbonne.

SIR ROBERT MOND has been elected an associate foreign member of the Académie des Inscriptions et Belles Lettres in Paris, in succession to the late King Fuad of Egypt.

PROFESSOR EMIL ABDERHALDEN, director of the Physiological Institute at Halle, has been elected an honorary member of the Cuban Society of Biology.

PROFESSOR FRIEDRICH ZAHN, president of the Bavarian Statistical Office, has been nominated president of the International Statistical Institute.

DR. HANS MOLISCH, professor of botany at the University of Vienna, celebrated his eightieth birthday on December 6.

DR. LANGLEY PORTER, a member of the faculty of the University of California for twenty years and dean of the Medical School for nine years, has consented to a rescinding of his recent retirement and will again assume the deanship, his reappointment to become effective immediately. This action was made necessary because of the sudden death of Dr. William McKim Marriott, who went from the deanship of Washington University Medical School to take Dr. Porter's place last July in conformance with retirement regulations. Dr. Porter will return to his post as an emergency measure with the understanding that efforts will be made to secure a new dean as soon as possible.

DR. HAROLD MESTRE has been appointed visiting associate professor and fellow in biophysics for the spring semester at Bard College, Columbia University, Annandale-on-Hudson, New York.

DR. E. G. ANDERSON, of the California Institute of Technology, will spend the period from December 15 to March 15 as visiting professor in the Division of Agronomy and Plant Genetics, University of Minnesota. Dr. Anderson is going to Minnesota in the absence of Dr. H. K. Hayes, temporarily on leave in China, to teach courses in advanced genetics, aid in the direction of seminars and assist with the genetics research program.

DR. WILLIAM H. TALIAFERRO, dean of the Division of the Biological Sciences of the University of Chicago Medical School, will spend the coming three months at the School of Tropical Medicine, at San Juan, Puerto Rico, conducting special research studies on the mechanism of immunity to trichiniasis. Dr. Lucy G. Taliaferro accompanies Dr. Taliaferro and is collaborating with him on this work, which is a joint project of the University of Chicago and the School of Tropical Medicine.

The Experimental Station Record reports that a laboratory for basic research in the biological and chemical problems of handling and processing citrus fruits and their products has been established by B. C. Skinner at Dunedin, Fla. Dr. R. B. Harvey, professor of plant physiology and botany at the Minnesota University and station, has been granted a year's leave of absence to take charge of the laboratory, which now has a staff of four coworkers. Attention will be given to improved methods of processing, utilization of cull citrus and other phases of citrus production and marketing.

DR. I. V. NEWMAN, who holds the Macleay fellowship of the Linnean Society of New South Wales and is known for his investigations of acacia, has been appointed lecturer in charge of botany at Victoria College, Wellington, New Zealand.

THE Faculty Committee on Research at Wesleyan University, of which Dr. T. A. Langlie is secretary, has made fourteen grants in various fields to members of the faculty. Those in science include the following: *Astronomy,* Professor Frederick Slocum, for assistance in computing work on photographic determination of the distances of stars and the measurement and reduction of photographs of the asteroid Eros; *Mathematics,* Professor Burton H. Camp, for computing aid in mathematical research; *Physics,* Professor Karl S. Van Dyke and Professor Walter G. Cady, for technical assistants to aid them in their work with piezo-electric resonators; *Psychology,* Associate Professor T. A. Langlie, for assistance in personnel research, with specific reference to Wesleyan University procedures with students; *Geology,* Assistant Professor Joe Webb Peoples, for the preparation of a monograph on the Stillwater Igneous Complex, Montana.

DR. RAYMOND W. WAGGONER, associate professor of neurology at the University of Michigan School of Medicine, has been appointed medical director of the State Psychopathic Hospital to succeed the late Dr. Albert M. Barrett, who was director for thirty years.

DR. JAMES SHELBY THOMAS, since 1933 president of the Clarkson College of Technology, Potsdam, N. Y., has been appointed head of the staff of the Chrysler Institute of Engineering. The institute was founded five years ago to permit graduate engineers in the engineering division to qualify for the master's degree. Since then it has been enlarged to include as under-

graduates other employees of the corporation. There are 1,000 students now enrolled.

THE address of Dr. G. E. Coghill, recently announced as Beaufort, N. C., is now Gainesville, Fla., where he expects to reside permanently.

DR. LEWIS H. WEED, professor of anatomy and director of the School of Medicine of the Johns Hopkins University, has been invited by the University of London to deliver the advanced course in anatomy. It is understood that he will lecture in London in the spring of 1937 and will choose for his subject "The Cerebrospinal Fluid."

DR. ARTHUR H. COMPTON, professor of physics, delivered the convocation address at the University of Chicago on December 15. The title of the address was "Can Science Point the Way?"

DR. RODNEY H. TRUE, chairman of the department of botany at the University of Pennsylvania, delivered a Sigma Xi lecture at the Massachusetts State College on December 7. He spoke on "Erosion."

DR. COLIN G. FINK, professor of electrochemistry at Columbia University, has planned a western trip during which he will speak before twenty local sections of the American Chemical Society, the American Institute of Mining Engineers and university groups on the following subjects: "Research in Electrochemistry," "Electrochemistry in Industry," "Corrosion" and "Chemistry in Art."

ERNEST H. ANTHES, director of the New York Division of the Bausch and Lomb Optical Company, visited the School of Tropical Medicine, San Juan, Puerto Rico, in December, where he lectured on the history of the microscope, its design and manufacture, with special reference to illumination methods.

THE annual Science Congress and Christmas lectures of the American Institute of the City of New York were held on December 28 and 29. The lecturers and their subjects were as follows: Dr. Harlow Shapley, director of the Harvard College Observatory, "Broadcasting from Antares"; Dr. Harrison E. Howe, editor of *Industrial and Engineering Chemistry*, "New Man-made Materials," and G. Edward Pendray, secretary of the American Rocket Society, "Rocketing through Space."

A DINNER in honor of the British Association was given recently by the Technical Group of the Forum Club, London. Miss Caroline Haslett, director of the Electrical Association for Women, presided, and the chief guest was Sir Josiah Stamp, president of the British Association. Other speakers were Sir Edward Poulton, president-elect of the association, and Professor William Cramp.

AT the Paris Exposition of 1937, an International Congress of Physical Education and Sport will be held during the week beginning July 14. The National Committee of French Sports and the president of the committee of organization, Dr. Collect, will have charge of the program. The object of the congress is to interest the French medical profession in encouraging boys and girls to take up sports in a more active manner than is at present the case.

FOUR fellowships named in memory of the late Dr. Arthur D. Little, for many years a member of the corporation, have been announced by Dr. Harry M. Goodwin, dean of the Graduate School of the Massachusetts Institute of Technology. Two of the fellowships will be known as the Arthur D. Little post-doctorate fellowships, carrying stipends of $1,500 each, with facilities for research in the institute's laboratories. The other two are to be known as the Arthur D. Little fellowships and entitle their holders to stipends of $1,000. They are open to graduate students pursuing studies for the doctor's degree in the fields of chemistry and chemical engineering, respectively. The announcement was made in connection with the dedication of the industrial museum which has been established at the headquarters of the Arthur D. Little Company on the occasion of the fiftieth anniversary of this widely known research organization.

THE College of Mines and Metallurgy, a branch of the University of Texas, has been unanimously accepted as a member of the Association of Colleges and Secondary Schools of the Southern States. Membership of the College of Mines followed application made last year and an examining tour by a survey committee of the association, composed of M. C. Huntley, executive secretary of the association; D. M. Key, president of Millsaps College, Jackson, Miss., and Dr. B. Gould, Sophie Newcomb College, New Orleans, La.

DISCUSSION

THE EARTH'S CORE

ONE of the problems that has long puzzled seismologists is the nature of the earth's interior. That the earth is not a homogeneous body has long been known. The existence of a definite core some half the diameter of the earth seems well established. Reflected waves from this core and refracted waves through it seem to identify its existence beyond reasonable doubt. But what is the nature of the core? Is it solid liquid or gas? Let us see some of the conditions it must satisfy.

In density it must be such as to allow of a mean density of about 5.5 as concluded from the results of Boys and others. Accepting Gutenberg's radius of the core, this would seem to require (following Jeffreys) a core density of about 12 (crustal density 4.2). This comparatively high density of the core has led to the general view that it is metallic—iron, nickel and such substances being mentioned as possible constituents.

In the matter of rigidity, the core must be considerably less rigid than the shell if the total rigidity is to fit in with that demanded by tidal phenomena and the Eulerian nutation. Jeffreys suggests the zero rigidity of a liquid core.

In its behavior to shear waves it is difficult to say what conditions the core must satisfy. In view of the identification of core shear waves claimed by Macelwane, Krumbach, Imamura and Bastings, it seems that the core must be capable of transmitting a shear wave, but with considerable loss of energy as compared with the compressional wave. The compressional waves are quite prominent after passing through the core, whereas, apart from the isolated cases of identification mentioned above, the shear wave fails to appear.

In view of these required conditions, the picture of the core that most nearly suits our facts is a solid metallic core heavily occluded with some such gas as hydrogen. Experiments with palladium occluded with several hundred times its own volume of hydrogen have revealed effects on its elastic constants that point in this direction. Such a solid metallic sponge for core would seem to give the right values for density, rigidity and small shear wave energy. Experiments to determine the effect of occlusion on elastic properties and particularly on shear wave energy are being carried on. Their results will be published shortly.

JOSEPH LYNCH

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CELL INCLUSIONS AND THE LIFE CYCLE OF AZOTOBACTER CHROOCOCCUM

FOR some time the writer has been engaged in a study of the so-called life cycle of *Azotobacter chroococcum*. While these experiments have not been brought to completion, one point of particular significance may be recorded here. A search of the literature reveals the fact that much confusion exists concerning the nature of the granular bodies which are invariably present in the cells of *Azotobacter* at certain periods of growth.

Jones[1] noted two types of granules which differed from each other in staining capacity. Some of the granules were not stained by aqueous solutions of aniline dyes, while others became intensely stained. He regarded the stainable bodies as reproductive cells or gonidia. Löhnis and Smith[2] made similar observations and conclusions. Mencz[3] regarded the granules as a chromidial system and the equivalent of a true nucleus. Prazmowski[4] believed that each cell contains one nucleus which divides preceding cell division. Schmidt[5] reported the presence of volutin. There is no indication that any of the other workers performed microchemical or solubility tests to determine whether the stainable bodies are living entities of the cell or lifeless cell inclusions which function as reserve food. In the absence of precise knowledge concerning the true nature of the granular bodies, any theory as to their function must be doubted.

Experiments were performed, therefore, to determine the reactions which occur when standard tests for fat, volutin and glycogen are applied. The colorless granules are readily identified as fat bodies, while the stainable granules consist of volutin. It is obvious, therefore, that these bodies could not perform the vital functions assigned to them by previous writers. So far as this species is concerned there seems no support for the conception of a life cycle which involves reproduction by means of gonidia.

Additional work is in progress dealing with reproduction by symplasm, conjunction and endospore formation and the question of cell transmutation. The results of this study will be published elsewhere.

I. M. LEWIS

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THE NEW AMERICAN DICTIONARY

NOTICE of publication by the University of Chicago Press of Part 1 of "A Dictionary of American English" has undoubtedly come to the attention of many American scientists, but perhaps few who have not actually seen the work are aware of its importance scientifically.

This dictionary, based on historical principles, is compiled under the editorship of Sir William Craigie co-editor of the Oxford English Dictionary. In a letter I received from Professor Craigie in 1928, when the work of compilation had barely begun, he stated "The New Dictionary will not aim at the inclusion of purely scientific terminology, but it ought to include the popular names of animals, birds, etc., so far as these can be historically traced." In this particular aspect the dictionary is succeeding admirably and

[1] Dan H. Jones, *Jour. Bact.*, 5: 325, 1920.

[2] F. Löhnis and N. R. Smith, *Jour. Agr. Res.*, 6: 67[illegible] 1916.

[3] E. Mencz, *Arch. f. Protistenk.*, 22: 1, 1911.

[4] A. Prazmowski, *Centralblt. f. Bakt.*, etc., II Abt., 3[illegible] 292, 1912.

[5] E. W. Schmidt, *Centralblt. f. Bakt.*, etc., II Abt., 5[illegible] 44, 1920.

adequately, to a degree that should make the work a valuable addition to the scientist's library.

The dictionary, as its name implies, has to do primarily with words found to be indigenously American, and every word or sense of a word that originated within the present limits of the United States is conspicuously indicated as such. For instance, although the word *alkali* is found in English before 1600, there are three senses of the word listed as peculiarly American, as well as the expressions alkali desert, alkali dust, alkalied, alkali flat, alkali grass, alkali lake, alkali plain and alkali sink.

The thoroughness with which the vernacular names of American plants and animals are treated is illustrated especially under the word *American* itself, where no less than eighty biologic and ethnologic terms, ranging from *American antelope* to *Amerindian*, are given with their definitions and histories. For method of treatment let us quote one example:

+**American chestnut.** The ordinary chestnut (*Castanea dentata*) of the United States. Also attrib. with *tree*.

1785 MARSHALL *Amer. Grove* 46 American Chesnut Tree. . . . The timber is used much for rails, splitting free and outlasting most of our Oaks. **1832** BROWNE *Sylva Amer.* 131 The American chesnut sometimes attains the height of 70 or 80 feet with a circumference of 15 or 16 feet. **1859** HILLHOUSE tr. *Michaux's Sylva* III. 12 Though the American Chestnut nearly resembles that of Europe in its general appearance, its foliage, its fruit, & the properties of its wood, it is treated by botanists as a distinct species. **1901** MOHR *Plant-life Ala.* 468 American Chestnut. . . . Important timber and nut tree.

The number of words purely American in origin is surprising; of these the following examples are selected to represent various branches of science and invention: *abalone, adobe, Alabama, alewife, amberjack, ambrotype, anaesthetic, ancon* (sheep), *angleworm, Appalachian, Arizona, Arkansas, automobile, Bad Lands.* Words originating after the end of the nineteenth century are not admitted to the dictionary.

For any one even only mildly interested in etymology or natural history or geography this dictionary makes good reading, as in fact any good dictionary does. Part 1 (A to Baggage) runs to 116 double-column quarto pages, and there are to be about 20 parts issued separately. By the time it is completed, judged from the beginning, the words of scientific import will mount to a considerable total.[1] It is to be hoped that scientific libraries, museums, and even individuals who can (Part 1 sells for $4) will avail themselves of this monumental reference work, the value of which is bound to increase as Americans become more and more aware of the richness of their own history and culture and put increasing store by the things that had their beginnings in their own country—the United States. In any event, the University of Chicago, the American Council of Learned Societies and the General Education Board of New York should be congratulated for sponsoring such a notable piece of literary research.

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SCIENTIFIC BOOKS

RECENT BOTANICAL BOOKS

The Story of the Plant Kingdom. By MERLE C. COULTER. ix + 270 pp. 119 figs. The University of Chicago Press, Chicago. 1935. $2.50.

MANY students still elect to go through a college course with very little training in science. This applies to certain pre-professional groups—such as those looking forward to law or journalism—who may be pressed for time; but it also holds for many who are not planning to enter such disciplines—the so-called "straight A.B.'s." In spite of the crowded programs and natural reluctance, the college graduate of this generation should live more richly if he has some understanding of the physical and natural sciences, along with the more traditional training in mathematics, the social sciences, the arts and the humanities. A remedy for the educational shortcoming that has thus existed is being tried in the survey courses that are now offered in some universities.

The text-book fruit of this type of course is beginning to mature; and it is to be expected that it will vary widely in different institutions. "The Story of the Plant Kingdom" is a volume that has been prepared for the "Introduction to the Biological Sciences," one of the courses of the "new plan" at the University of Chicago. We are told that the course in biology includes "indispensable readings" in ten books, of which this is one.

Nothing revolutionary has been attempted in this volume. The material presented is for the most part that which is included in the standard texts. Reversing the usual order, this book begins with a consideration of "primitive plants," especially the blue-green algae, and then traces the evolutionary development up through the algae, fungi, liverworts, mosses, ferns, horsetails, club mosses and seed plants. Only well on in the presentation are the structures and functions of the higher plants considered. There is a chapter on the process of evolution and a concluding chapter on some of the commoner families of the angiosperms.

Any book which treats the general subject of botany

[1] The prefatory note to Part 1 states: "In A, the largest group of words denoting actual things consists of the names of plants or trees and animals."

in a short space must omit or pass lightly by some of its aspects. If the volume under consideration is considered in its entirety—only twelve of the twenty chapters constitute "indispensable reading"—then relatively more emphasis than usual is placed upon the evolutionary development and life cycles of plants, and relatively less on the functions of the higher plants; very little attention is given to plant inheritance.

The book is written in simple, easily understandable, rather narrative style. The 119 figures are all original, and consist mostly of somewhat simplified, clear drawings and some good half-tone reproductions of photographs.

Those who come to their botany by way of "The Story of the Plant Kingdom" should gain an appreciation of the more classical and fundamental aspects of the science; they should be able to visualize the broad evolutionary panorama as it unfolded in ages past, and understand it; and they should acquire some insight into the nature and workings of the higher plants. They will not be burdened by a host of details, nor will they achieve the understanding and the pleasure that real intimacy engenders.

Botany: A Textbook for Colleges. By J. BEN HILL, LEE O. OVERHOLTS and HENRY W. POPP. xiii + 672 pp. 335 figs. McGraw-Hill Book Company, New York and London. 1936. $4.00.

THIS volume aims to present the material and interpretations of a two-semester college course in general botany. It gives an unusually comprehensive survey of the whole field of botanical science.

A general introduction is followed by a brief chapter on "Coloration in Plants," a feature which is so obvious in the autumn when most students begin their formal study. Otherwise the plan followed is similar to that of the majority of texts, the first half of the book being devoted to the structure and activities of the higher plants, the second half to evolutionary development. Inheritance is considered at the very end.

The organs of the seed plants are discussed in detail. In the chapter on the stem, for instance, in addition to the data usually presented on the external characteristics and the internal anatomy and development, the various types of bundles and of steles are described and figured. There are chapters each on "Food Synthesis," "Absorption of Water and Inorganic Salts," "Growth and Movement" and "Digestion, Respiration, Fermentation." There is hardly another general text in which one could find, for example, a discussion of photoperiodism, grand period of growth, presentation period, autonomic and paratonic movements, nasties and taxies.

The second part of the book, dealing with the divisions of the plant kingdom, similarly goes into considerable detail. Thus in the chapter on the gymnosperms, the Cycadofilicales, the Bennettitales, the Ginkgoales and the Gnetales are discussed, together with the more usual Cycadales and Coniferales; and among the last named some of the less commonly known genera, such as *Torreya* and *Agathis,* are mentioned and illustrated.

In the chapter on the "Families of Angiosperms" the authors have had the courage to depart from the sequence followed in the manuals; they discuss the dicotyledons before the monocotyledons. The buttercup and rose families are considered first in the dicotyledons, and the willow family last. The cat-tail family is taken up at the end of the monocotyledons.

Nearly all the abundant illustrations are original; this gives the volume a pleasantly new flavor. The style is simple, clear and not very animated. Summaries and bold-face type are used, with discretion, however, so that the reader has the privilege of doing some thinking for himself. The facts and interpretations are not presented dogmatically, and the whole field is portrayed as one that is still growing and expanding.

This book is no child's play. As a text to be used in a general elementary course, it is a tribute to the diligence of the authors and to the seriousness of the students for whom it is intended.

Practical Problems in Botany. By WILFRED W. ROBBINS and JEROME ISENBARGER. ix + 402 pp. 230 figs. John Wiley and Sons, New York. 1936. $2.00.

THIS volume is intended for use in a course in botany for "high school classes, especially if preceded by a course in general science or one in general biology." The authors aim to establish "a foundation of fundamental principles which will enable pupils to develop an understanding of the significance of plant life which is such an important part of their environment."

The text is composed of ten units, each introduced by its own preview; these ten divisions concern themselves with the organization and composition of plants, nutrition of green and non-green plants, growth, reproduction, dependence upon and adaptation to environment, the development, improvement, classification and economic importance of plants. Each of these units is then in turn subdivided into from four to ten "problems." The 63 problems thus outlined are treated in considerable detail, each with a thorough discussion. An unusually large amount of material is presented within these pages.

The outlook of the book is scientific, but economically significant and otherwise interesting features are

emphasized throughout. Thus some fifteen pages are devoted to a lucid discussion of artificial propagation in which stem, root and leaf cuttings, layering, suckers, runners and the various types of grafting are succinctly described. Similarly, the unit on the economic importance of plants to man deals with such mundane but nevertheless vital subjects as the various food plants from the cereals to the spices, beverage plants, fiber plants, wood, coal, cork, resins, turpentine, gums, dyes, oils, rubber, medicinal plants, weeds, poisonous plants and hay-fever plants. The evolutionary development of plants, while not overlooked, is not used as the theme of at least half the book, as is so frequently done in college texts.

The bulk of the book is devoted to the presentation of basic facts and principles. But those who are susceptible to mental stimulation will find ample opportunity for reflection in the 144 "exercises," many of which consist of several parts, the very numerous "additional questions and exercises" and the frequent "suggested activities." The well-chosen references will guide those who seek to go farther afield.

Paragraph headings and bold-face type are used extensively; but the style is not unpleasant nor is the reading difficult. The 230 figures, consisting of drawings and photographs, are simple and well selected; they are mostly original.

The student who has read, digested and assimilated the contents of this volume will have acquired a good grounding in the principles of botany; he will have learned many of the facts on which they are based; and he will have become acquainted with the humanly important applications of the science.

A Manual of Southern California Botany. By PHILIP A. MUNZ. xxxix + 642 pp. 310 figs. Claremont Colleges, Claremont, California. 1935. $5.00.

IT seems a little strange that despite the philosophical and penetrating analyses of Asa Gray our manuals should to this day be essentially compilations of descriptions of genera and species, coupled with brief notes on distribution and sometimes on time of flowering. Only with exceeding slowness have the challenging and important features of plant distribution been unravelling. This subject, to be sure, is still far from complete, but it has reached a stage at which it is now possible for students living in certain parts of the country to gain not merely a knowledge of the plants of their flora, but an understanding of that flora as well.

Those who live in southern California are especially fortunate in having in this volume an account of the development of their flora as well as the descriptions of the genera and species of which it is constituted. A discussion of some twelve pages is devoted to the distribution of the plants of southern California, in which such important geological changes as the submersion of large areas in the Eocene, Miocene and Pliocene, the glacial and interglacial conditions of the Pleistocene and the uplifts in the Tertiary are taken up. Next the physiographic features are considered; these include the Colorado and Mohave deserts, the various mountain regions, the "cismontane" areas and the islands. The characteristic plants of these regions are listed. The relationships with the north, with the Rockies, with deserts and the south and with islands are discussed; affinities with South America and the Mediterranean region are also mentioned. Throughout, the relatively high proportion of endemism is emphasized and explained on the basis of isolation.

Then follow a key to the families, and the descriptive flora, from the pteridophytes through the angiosperms. There are family and species keys, as usual. The family, genus and species descriptions are terse and sufficient. Brief ecological and distributional notes accompany the account of each species. Varietal differences are commonly given; it is possible to do this, since the volume deals with a relatively limited region. Three hundred and ten of the species are illustrated by well-drawn figures.

The botanically minded of southern California may rejoice in having both an authoritative and interpretive account of their own flora. Although less pretentious in its design than so many manuals, it gains by the familiarity with details that an intensive study of a more limited area alone makes possible.

An Illustrated Manual of Pacific Coast Trees. By HOWARD E. MCMINN and EVELYN MAINO. With lists of trees recommended for various uses on the Pacific Coast. By H. W. SHEPHERD. xii + 409 pp. 415 figs. University of California Press, Berkeley, California. 1935. $3.50.

ONE of the most discouraging features confronting those who aim to become acquainted with the plants of any fairly well-populated region is the distinction between "wild" and "cultivated" forms. This is the result, in part at least, of a certain inherent disdain with which the latter are treated by so many professional botanists. The "escapes" have tended to eliminate this barrier to some extent, but there are relatively few books that give both native and introduced plants together. In this regard the volume under consideration is a happy exception to the majority.

All the known species of trees, and some varieties native to California, Oregon, Washington and British Columbia are described—146 in all—together with some 400 introduced forms which have been planted as ornamentals in gardens and parks and along highways. These are grouped into families essentially

according to Engler and Prantl. The genera are keyed out largely on leaf characters. They are listed alphabetically in each family, each being discussed, and then the species are keyed. The species descriptions are brief but readable and give the outstanding characteristics in clear, concise fashion. A short note on distribution accompanies each account. There is nothing stifling about these species portrayals—in fact, they rather beckon.

The great majority of species are figured by exceptionally clear and rather artistic drawings of the leaves, in most cases of the fruits, and occasionally of the flowers. All the illustrations are original. The authors have shown good sense in making enlarged illustrations of the small leaves of such genera as *Callitris, Chamaecyparis, Cupressus, Juniperus, Libocedrus* and *Thuja*. Forms like *Dracena, Yucca, Musa* and the palms are effectively shown by photographs of the entire plant.

Such general topics as the leaf, flower, inflorescence, fruit and seed are discussed in a rather elementary way in the introduction. These are followed by a consideration of the origin and distribution of Pacific Coast trees, in which four sources are given: the subarctic and cool-temperate regions of the northern hemisphere, the arid Southwest and northern Mexico, the Great Basin and Rocky Mountain region and the Pacific Coast. The forms characteristic of each of these are listed. Because of the varied climate of the Pacific Coast, trees from the four corners of the earth have been introduced there—from the Himalayan region, various parts of Africa, Australia and New Zealand, as well as from Mexico, eastern and central United States and Canada. The climatic similarities between those regions and certain parts of the Pacific Coast, which have made their introduction there feasible, are elucidated.

The final pages of this volume are devoted to lists of trees recommended for various uses on the Pacific Coast. Intended primarily for the horticulturist, these lists include trees particularly desirable from such diverse standpoints as: alkali, drought and heat tolerance; autumn foliage; appropriateness in borders, hedges, lawns and avenues; erosion control; flower production; pest resistance; speed of growth; and numerous others.

The authors have produced a volume that may be considered a distinct contribution in many ways, especially because of its relative simplicity and ease of use, its broad scope and its uniformly excellent illustrations.

Krakatau, 1883–1933. *A. Botany.* By W. M. Docters van Leeuwen. xii + 506 pp. 10 figs. 36 plates. E. J. Brill, Leiden. 1936.

This volume summarizes and interprets the original work of a number of men, including the author, on the three volcanic islands of the Krakatau group, and especially of Krakatau itself.

The great eruption of Krakatau occurred in 1883, and so the present work presents the results of some fifty years of investigation. After a critical evaluation of the evidence, Docters van Leeuwen concludes that the vegetation was obliterated completely at that time. Situated between Java and Sumatra, the Krakatau group is consequently very favorable for ecological study. A comparison is made with more or less similar areas, such as Volcano Island, parts of Japan, Tarawara Mountain in New Zealand, Katmai in Alaska, and others. The botanical investigations of various collectors in Krakatau are then discussed, from the early ones of M. Treub in 1886 to the more recent ones in which the author was active.

The Cyanophyceae were "pioneers on the soil," and they were followed by mycorrhizal ferns. In 1886 eleven of the twenty-six species of vascular plants were ferns; in 1934 only fifty-two of two hundred seventy-one were pteridophytes, the majority of the remainder being dicotyledons. Four possible methods of distribution are suggested for these plants: wind, water, animals or man. It is estimated that the plants disseminated especially by wind contribute some 41 per cent. of the total of 271 species; approximately 28 per cent. were carried by water; some 25 per cent. were brought in various ways by animals; and about 15 species, or nearly 6 per cent., were brought in by man. These last, including some common weeds, did not thrive well.

One chapter is devoted to "Associations and Successions," in which grass associations, ferns, shore types and forests are considered.

In the last two hundred pages of the volume the galls that have been found on the islands—some of them are known only from Krakatau—and the various species of mosses, hepatics, pteridophytes and spermatophytes that have been collected are discussed. In some cases, for instance in the coconut, an extensive account of the adaptations for dispersal is presented.

The story of the vegetative recapture of these islands is graphically portrayed in the sixty photographs; those taken in 1928 and 1932 form a very striking contrast to those of 1886.

The book is a translation, and the style is not smooth. The whole work might gain in general interest if it were less polemic.

Docters van Leeuwen has made an important contribution to the botany of this unique and ecologically fascinating group of islands.

Edwin B. Matzke
Sam F. Trelease

Columbia University

ABSTRACTS OF PAPERS PRESENTED AT THE CHICAGO MEETING OF THE NATIONAL ACADEMY OF SCIENCES

Some recent advances in the theory of the calculus of variations: G. A. BLISS. Problems of the calculus of variations with variable end-points were considered early in the history of the subject. One of the first was that of finding, among the arcs joining two fixed curves, one down which a particle starting with a given initial velocity will fall in the shortest time under the action of gravity from one curve to the other. When the two fixed curves are replaced by two fixed points the problem is said to have fixed end-points. The case when both end-points are variable was studied by Lagrange in 1762. He made an error which he corrected in a paper of 1770, where he also formulated a much more general problem of the calculus of variations with variable end-points. Since that time the theory of problems with fixed end-points has been highly developed, but the theory of problems with variable end-points has lagged behind. In 1913 Bolza formulated a problem of the latter type which at present seems the most widely applicable. Recent papers by M. Morse and myself have brought the theory of this problem to a stage comparable with that of the theory of problems with fixed end-points. Important improvements were added by M. R. Hestenes while he was my research assistant and in later papers, and by L. M. Graves. Their results afford significant advances for the theory of problems with fixed end-points also, since they are deduced without the assumption of normality on sub-intervals customarily made by preceding writers, and apparently also without any assumptions of normality whatsoever. I have recently discovered, however, that on the basis of their hypotheses one can construct a problem for which the arc considered is normal, though not necessarily normal on sub-intervals, and by means of which the sufficiency theorems of Hestenes can be attained. Thus the normal case still appears to be the most important one. This is the result which I emphasize especially in this paper.

Remarkable results in additive number theory: L. E. DICKSON.

Polynomial approximation on a curve of the fourth degree: DUNHAM JACKSON. At a recent meeting of the American Mathematical Society the writer discussed the formal properties of polynomials in two real variables which are orthogonal on a curve in the plane of the variables. In the simplest cases, when the curve is a line segment or a circle, the resulting series developments reduce essentially to Legendre and Fourier series, respectively, so that in those cases new problems of convergence do not arise. The present paper is concerned with questions of the convergence of polynomial approximation on a particular curve of the fourth degree, for which the results are new in substance as well as in form.

Photoelectric guiding of astronomical telescopes: A. E. WHITFORD and G. E. KRON (introduced by Joel Stebbins). During long photographic exposures the astronomer must have his eye fixed at the eyepiece of a telescope in order to keep the instrument centered exactly on the object being photographed. The "automatic guider" in this paper delegates this tedious and exacting task to a photoelectric cell. The principal difficulty is the extremely small amount of light available to actuate the mechanism, so that the feeble impulse from a star must be amplified as much as a billion billion times. The use of the new Zworykin electron multiplier has made it possible to extend the working limit somewhat beyond that attainable by conventional methods of amplification. The control is exercised entirely through electron tubes, without mechanical relays. Preliminary tests on the 60-inch telescope of the Mount Wilson Observatory show that the device performs satisfactorily on stars down to about the eighth magnitude. The development of the new instrument is part of a program of research in connection with the 200-inch telescope of the California Institute of Technology.

The colors of stars in a region in Sagittarius: JOEL STEBBINS and ALBERT E. WHITFORD. With a photoelectric amplifier attached to the 60-inch telescope at Mount Wilson, measures of the brightness and color of seventy-five stars were made in a region about five degrees square in the constellation Sagittarius. Most of the stars are in a bright star cloud of the Milky Way, which is bordered by dark areas having the appearance of absorbing clouds of dust in space. Stars which shine through dense portions of the dust are found to be redder than stars out in the clear; the degree of reddening indicates the amount of dust between us and a star. The distances of stars can be measured by triangulation to two or three hundred light-years; farther than that the distances can be estimated by the apparent brightness of the stars. The stars here studied are two thousand light-years away. The region is toward the center of the galaxy, but the center is much farther, about 30,000 light-years, and no telescope will reach the center because of the obscuring dust. Even though this star cloud and others in the neighborhood appear as the brightest parts of the Milky Way, the measured reddening of stars shows that there is a thin veil of dust over this entire region of the sky, while in the opposite direction, away from the center of the galaxy, stars like those in Orion are white because we see them through much less dust.

The empirical mass luminosity relation: G. P. KUIPER (introduced by F. R. Moulton).

The 82-inch reflector of the McDonald Observatory: GEORGE W. MOFFITT (introduced by F. R. Moulton).

Solar activity recorded by the motion-picture method at the McMath-Hulbert Observatory of the University of Michigan: ROBERT R. MCMATH and EDISON PETTIT (introduced by Heber D. Curtis.) The new solar tower of the McMath-Hulbert Observatory of the University of Michigan is located at Lake Angelus, near Pontiac, Michi-

gan. It was completed on the first of July of the present year and is the sixth solar tower in the world in point of time. In certain elements of design, however, it is believed to be the most efficient in existence, and is also certainly the most convenient in use. The paper presented consisted essentially of a motion picture film showing a general view of the new tower telescope of the McMath-Hulbert Observatory and certain important constituent parts of the special mechanisms contained therein. Following the above, the prominences were displayed in motion in sequence according to the classification of Dr. Edison Pettit, of the Mount Wilson Observatory. As far as is known, these pictures are the first continuous large scale records of solar prominences, although in point of time the first successful continuous record of solar phenomena were pictures taken at this observatory on a smaller instrument in June, 1934. Preliminary measurements indicate motions varying from 30 kilometers per second to 150 kilometers per second. The motions of the various types of solar prominences are very well shown by these pictures and afford an astronomer his first opportunity of actually reviewing with his own eyes these motions. We see no evidence that light pressure alone will, in any way, satisfactorily explain the activity of these prominences and all appearances favor an electrical theory of prominence formation, motion and destruction. Also it is apparent that a substantial portion of the material in motion travels towards the sun-spot area. We are indebted to H. E. Sawyer, J. T. Brodie and R. C. Williams, who have acted as solar research assistants during the entire period covered by this film.

A projection method for ascertaining the heights, shapes and dimensions of the surface features of the moon: F. E. WRIGHT. The moon is so nearly spherical in shape that, for local measurements, it may be considered to be spherical without sensible error. A photograph of the moon is a perspective projection of its surface on the diametral plane of the sphere normal to the line of sight. For each lunar photograph the exact time at which the exposure was made is recorded; hence the phase angle (angle at the moon's center between the directions to the centers of the sun and the earth, respectively) is known. If, therefore, an accurate lunar polar perspective projection plot be prepared and superimposed on a given lunar photograph of the same diameter the elevation angle (complement of the angle of incidence) of the sun's rays at any point on the moon's surface can be read off in the projection. If, for example, the angle of elevation of the sun's rays is less than the angle of slope of an inner crater wall, the wall casts a shadow; if the elevation is greater, the slope is illuminated; when elevation and slope angles are equal, grazing incidence is observed. Distances are read off directly on the projection in angular measures, and these in turn are reduced to linear measures by use of a conversion table. The height of a given feature is determined from measured data of measurement on slope angles and distances. This method enables the geologist to ascertain relative heights, depths, shapes and dimensions of lunar surface features with a satisfactory degree of accuracy and with little computation. The measurements are all made with the aid of accurate polar and meridian perspective projection charts superimposed, usually by optical projection, on lunar photographs. Preliminary measures on photographs taken with the 100-inch telescope at Mt. Wilson Observatory show that the inner slopes of small craters (craterlets) are in general steeper than those of larger craters and walled plains; their slope angles may reach 50° to 55°. The committee of the Carnegie Institution of Washington on study of the surface features of the moon is applying this method to study of the physiography of the moon's surface. To facilitate this study a large series of photographs of the moon during an entire lunation is to be taken in the near future with the 100-inch telescope equipped with a special three-element Ross corrector lens at the Newtonian focus.

The pituitary gland of whales: E. M. K. GEILING. The pituitary gland of whales, which had hitherto not been studied except for the porpoise (Wislocki), offered promise of being suitable material for answering the following question: Where are the active components responsible for the multiple properties of so-called posterior lobe extracts elaborated? Are these principles formed in the pars intermedia, in the pars nervosa or in both? The more detailed anatomy of the hypophysis of whales has just been published by Wislocki and myself. To date four species have been or are being studied by us—the sperm (*Physeter megalocephalus*), the finback (*Balaenoptera physalis*), the blue or sulfur bottom (*Balaenoptera sibbaldii*) and the humpback (*Megaptera nodosa*). In all these species the adult gland is made up of a large, flattened anterior lobe and a smaller neural lobe; the latter is surrounded by a capsule derived from the leptomeninges, as well as by dura and subdural space, and is consequently entirely separated from the anterior lobe. The anterior lobe is embedded directly in the thick dural pad lining the floor of the whale's cranial cavity. There is no pars intermedia or a residual lumen present. The anterior lobe is relatively homogenous in character and is composed of acini of acidophil, basophil and chromophobe cells. With the techniques employed, the neural process is composed of a fibrillar substance containing relatively few well-defined cells and abundant blood vessels. No nerve cells are visible in any part of the neural hypophysis. Hyaline bodies of Herring are present in the neural lobe. Because of the anatomical separation of epithelial and neural lobes, these bodies can not be regarded as a product of any portion of the epithelial hypophysis, but must arise *in situ*. Furthermore, Gersh and Tarr have recently reported experiments indicating that the Herring bodies are artifacts and are not precursors of the pressor, antidiuretic and oxytocic principles. Extracts of the acetone-desiccated posterior lobe powder possess pressor, antidiuretic and oxytocic activity. The pressor and antidiuretic principle is present in the same concentrations as in the standard powder (beef), but the oxytocic principle is present in a much smaller concentration; in the finback and humpback whale there is about 40 per cent., in the blue whale 30 per cent., while in the sperm whale only 8 per cent. of the activity found in an equal weight of the standard powder (McClosky, Miller and LeMessurier). The melanophore principle is not in the posterior lobe, but in the anterior lobe. It is

concluded that the pressor and oxytocic components are elaborated in the neural lobe, and are not derived from the pars intermedia. The anterior lobe has the gonadotropic (follicle-ripening and luteinizing) hormones (the luteinizing principle in relatively smaller concentration, however, than in the sheep anterior lobe), and also the thyreotropic and adrenotropic principles (Lawrence). The prolactin content of the anterior lobe is very low; a good yield of follicle-stimulating hormone was obtained; and the presence of the thyreotropic factor was demonstrated (Riddle and Bates).

The effect of cortin upon the renal excretion and balance of electrolytes in the human being: F. A. HARTMAN, G. W. THORN, HELEN R. GARBUTT and F. A. HITCHCOCK (introduced by C. M. Child). Previous attempts to show a positive effect of cortin in normal subjects have met with little success. It has been found in our experiments that large doses of cortin injected intravenously produce a prompt effect on the kidney of a normal human being. Eighty cat units (three to four times the daily requirement for a patient with severe Addison's disease) administered over a period of four hours caused an average reduction of 42 per cent. in the sodium excretion. Potassium excretion was increased 30 per cent. In balance studies with subcutaneous daily injections of 12 to 30 cat units of cortin (the daily requirement of a severe case of Addison's disease) there was no effect on the electrolytes in eight normal subjects. The amount of hormone was sufficient to cause marked retention of sodium and chloride in patients with Addison's disease. Therefore it seems that there is a normal limit of cortin action beyond which a considerable increase is required to produce further effect.

The adrenal glands in diabetes: J. M. ROGOFF. For nearly thirty years an idea has prevailed that the function of the adrenal medulla plays an important rôle in pancreatic diabetes. In 1907, Zuelzer proposed the view that glycosuria following pancreatectomy is due to diabetogenic action of epinephrine secretion from the adrenals in the absence of antagonistic action of internal secretion of the pancreas. Since then evidence has been offered by various workers to support this view. It has been alleged: *a*, that pancreatic diabetes does not develop in the absence of epinephrine secretion and that interference with epinephrine secretion ameliorates the diabetic condition if present; *b*, that insulin requirement to control pancreatic diabetes is reduced if epinephrine secretion is reduced or suppressed; *c*, that reduction or suppression of epinephrine secretion increases sensitivity to insulin; *d*, that human diabetes is ameliorated or cured by roentgen irradiation of the adrenals or by surgical intervention with the glands to reduce epinephrine secretion. We have found that the development and course of experimental pancreatic diabetes is not modified by reduction or suppression of epinephrine secretion from the adrenals. The range of insulin dosage required to control glycosuria in depancreatized animals with reduced or suppressed epinephrine output is the same as in depancreatized animals not subjected to interference with epinephrine secretion. Sensitivity to insulin does not differ in these two groups. Furthermore, we observed that liberation of epinephrine sooner or later becomes reduced or suppressed in diabetic animals that have not been subjected to interference with the adrenals. This appears to be due primarily to the diabetic state of the animal, since it was found to occur in depancreatized dogs not treated with insulin as well as the treated animals. Indeed, marked reduction in liberation of epinephrine was found in control, unoperated dogs maintained for some weeks on a diet to which was added 100 grams of sugar daily, with or without administration of insulin. Liberation of epinephrine from the adrenals can be increased by electrical stimulation of the splanchnic nerve, up to or above the normal level, in those animals that show a marked reduction in output. In view of these observations, based upon quantitative investigations of epinephrine secretion from the adrenals in relation to diabetes, we consider the evidence for the conclusions stated by Zuelzer, and supported by others, untenable. Obviously, treatment of diabetes by roentgen irradiation of the adrenals or by surgical intervention with the glands or their nerves is not fundamentally sound. Such practices involve danger of irreparable damage to the indispensable adrenal cortex.

The character of the estrus-inhibiting substance in testis-tissue extracts: D. R. L. DUNCAN, T. F. GALLIGHER and F. C. KOCH (introduced by F. R. Lillie). Crude male-hormone preparations from testis tissue inhibit the normal estrus cycle in adult rats. Some investigators have interpreted this physiological response as due to the inhibiting action of the male hormone on the hypophysis. Our studies show that further fractionation of the testis male-hormone preparations involving the purification of the male-hormone fraction shows that the estrus-inhibiting activity is concentrated in the lipin fraction free from male hormone and particularly in the phospholipin fraction, but that the male-hormone activity does not parallel the inhibiting action. Lecithin and kephalin obtained from these products produce the same inhibition in doses equivalent to the original crude product. Crude cholamine and choline obtained by hydrolyzing these phospholipins or pure cholamine and choline prepared synthetically produce the same inhibition. Pure testosterone in doses twenty times those found in our crude testis-tissue concentrate do not inhibit the estrous cycle. We conclude that the estrus-inhibiting action in crude testis-tissue male-hormone concentrates is due to the phospholipins and not to the male hormone.

Enterogastrone: Proof of the existence and methods of assay: A. C. IVY (introduced by Ludvig Hektoen). Enterogastrone is a chalone which is produced by the intestinal mucosa, when an adequate amount of fat or sugar and possibly other substances enter the intestine, and which acts to reduce the motility and secretion of the stomach. The observations upon which the existence of enterogastrone is based are: (1) The introduction of fat or sugar into the intestine inhibits the motility and secretion of an autotransplanted pouch of the stomach or of a stomach whose intrinsic nerves have been sectioned. This unequivocally establishes the existence of a humoral or blood-borne agency. (2) The injection of dextrose, fatty chyle or the products of the digestion of sugar and

fat intravenously does not inhibit motility or secretion. This shows that the inhibition is not due to the absorption of the products of digestion of fat and sugar. (3) Appropriately made extracts of the mucosa of the upper intestine yield a substance which, when injected intravenously or subcutaneously, inhibit gastric secretion and motility, and which possess a number of the aspects of specificity. The steps in the proof remaining to be supplied are the chemical isolation of the substance and its identification in the blood or lymph. The substance has not been sufficiently concentrated to warrant its parenteral injection into a human subject. A unit of enterogastrone is that quantity, which when injected intravenously in a 12 to 14 kg dog with a pouch of the entire stomach and receiving sufficient histamine subcutaneously at 10-minute intervals to maintain a uniform flow of 1 cc of gastric juice (5 mg HCl) per minute, causes a 50 per cent. reduction in the secretion of hydrochloric acid during two hours following the injection of enterogastrone. Five one-hundredths of a unit will inhibit the movements of a stomach distended by a balloon containing 100 cc of air for about six minutes; one unit for about fifty minutes.

Mode of action of parathyroid extract on bone: FRANKLIN C. MCLEAN and WILLIAM BLOOM (introduced by A. J. Carlson). Very large doses (1,000 units) of parathyroid extract were administered to growing rats. Within six hours many of the osteoblasts died; the majority, however, changed into fibroblasts or osteoclasts, or became phagocytic. Within twelve hours a large proportion of the bone cells were necrotic, especially in the rapidly growing spongiosa of the long bones, and the number of osteoclasts had greatly increased by development from osteoblasts and reticular cells. Within twenty-four hours the necrotic bone tissue had been largely resorbed and replaced by scar tissue, containing a large number of osteoclasts, thus producing the typical picture of osteitis fibrosa generalisata. Recovery occurred by extensive intramembranous formation of new bone, accompanied by development of large numbers of active osteoblasts from the fibroblasts of the scar. These observations throw new light on the pathogenesis of experimental osteitis fibrosa, which appears to develop, in part at least, as a reaction to the death or injury of the cellular elements of bone. Of more general biological interest is the evidence that osteoblasts are not permanently differentiated cells, for they have been seen to change into phagocytes, osteoclasts and fibroblasts; further, fibroblasts have been seen to develop into osteoblasts which were then associated with the formation of new bone. This, then, is an example of controlled reversible cellular differentiation.

The mechanical efficiency of the heart as a measure of its fitness: M. B. VISSCHER (introduced by F. R. Lillie). In these studies, the oxygen consumption of the heart and the work performed by it were measured as described by Peters and Visscher. The dog's heart in the Starling Heart-Lung preparation was employed. Previous work, particularly by Starling and collaborators, has shown that the energy liberation with variations in load on the heart is determined by the length of the muscle fiber at the beginning of contraction. The fiber length is obviously determined by the volume of the ventricles of the heart, so it can be stated that volume of size of the heart at the end of diastole is the factor determining the liberation of energy in the succeeding contraction. Hearts were made to work for periods long enough to permit them to undergo acute failure and the quantities of energy liberated and work performed measured. The hearts were made to work at constant diastolic volume, that is, initial fiber length. Two important interrelated facts became apparent. First, as the heart became less able to perform work the energy output per contraction at uniform initial fiber length remained virtually constant. Obviously in this type of heart failure the defect is not a progressive inability of the muscle to liberate a normal quota of energy upon contraction. There is rather a failure on the part of the muscle in its ability to convert as large a fraction to useful work. Thus there was found to be an important decrease in the efficiency of heart muscle in the process of failure. The fact previously referred to, namely, that the heart automatically adapts itself to its load by increasing its volume and thus its energy liberation when it is unable to eject as much fluid per unit of time as enters it, necessitates that in order for a failing heart to carry a uniform load it must dilate. Thus a heart which must dilate greatly to perform a small load of work is an inefficient machine. In clinical terms such a heart is ordinarily described as having poor tone. In physical terms the tone of the heart muscle is shown by these studies to be in reality synonymous with its mechanical efficiency or its fitness to carry its load. In a further series of experiments the mechanism of action of certain cardiac drugs was investigated in relation to this question. It was found that the most useful glucosides of the digitalis series, employed in therapeutic doses (about 0.1 mgm per liter of blood) showed a prompt and large effect in restoring the efficiency of failing hearts toward the normal. It seems likely that these agents have their beneficial action through this mechanism. A new experimental criterion for the evaluation of cardiac drugs is available by the use of these methods.

The regulation of body temperature by the hypothalamus: S. W. RANSON (introduced by C. J. Herrick).

The rôle of stimulative and inhibitive induction in the development of primary and secondary sex characters: EMIL WITSCHI (introduced by F. R. Lillie). Previous studies showed that in the development of the vertebrate gonad the cortex acts as an inductor of ovarian differentiation and the medulla as an inductor of testicular differentiation. Thus sex is determined on the basis of a competition between two inductors, each of which stimulates differentiation of one sex and tends to prevent development of the other. New experiments on the nature of the inductors are presented which support the following conclusions: (1) Each inductor has a double function, stimulative and inhibitive. (2) Stimulative induction is transmitted from the inductor to the reacting tissues mainly by direct contact and therefore spreads only over a narrowly limited district. (3) Inhibitive induction has always

wider range and in the extreme assumes the character of a typical hormonal reaction, transmitted by the blood stream. (4) It appears therefore that each inductor produces and releases at least two different inductive substances which are designated as *cortexin* + and *cortexin* – in the case of cortical products and *medullarin* + and *medullarin* – in the case of medullary products. (5) These inductive substances are not identical with the sex hormones of the mature sex glands which control the functional development of secondary sex characters.

Effect of galactic rotation on cosmic rays: ARTHUR H. COMPTON. Because of the rotation of the galaxy, the earth moves at about 300 km per second toward R.A. 20 h 40 m and declination 47° N. As a result of this motion, Dr. Getting and the author predicted a variation with sidereal time of about 0.1 per cent. (within a factor of 2) at 45° latitude and a difference of intensity between 45° N and 45° S latitude of about 0.5 per cent. During the past year the existence of a sidereal variation of the predicted amplitude and phase has been reported in the northern hemisphere by W. Illing, and in the southern hemisphere by B. F. J. Schonland and his collaborators. New measurements by R. N. Turner and the author provisionally confirm likewise the predicted difference between the northern and southern hemispheres. This quantitative confirmation of the predictions implies: (1) The astronomer's estimate of the rate and direction of galactic rotation is roughly confirmed, and no indication appears of a motion of the Milky Way as a unit relative to the source of cosmic rays. (2) The source of most of the cosmic rays is beyond our galaxy. (3) The agreement with prediction is satisfactory only if the cosmic rays are electrically charged particles.

Approximately relativistic equations for nuclear particles: G. BREIT (introduced by A. H. Compton). Cosmic ray showers indicate that at high energies the forces between protons and neutrons are intimately concerned with the creation and destruction of matter. Complete theories of the nucleus will, therefore, probably contain these phenomena as an integral part, and a full inclusion of the principle of relativity in the theory of the nucleus is presumably impossible without bringing in the electro-neutrino field or its equivalent. At present no satisfactory view of this kind is available. For most practical purposes it is nevertheless possible to form much simpler theories, including the effects of relativity and allowing one to compute the interactions between orbits and spins of nuclear particles. In this paper possible forms of such theories are enumerated. By means of them the fine structure of energy levels in the nucleus can be calculated. Comparison with experiment is made and is found to be satisfactory.

The intermediate product in nuclear reactions and disintegration in steps: WILLIAM D. HARKINS. (Read by title.)

Anisotropy in the atomic vibrations of zinc crystals as revealed by the scattering of x-rays: G. E. M. JAUNCEY (introduced by Joseph Erlanger). About a year ago Brindley and Spiers reported anomalous intensities for certain x-ray reflections at room temperature from powdered zinc crystals. These anomalous intensities indicated that the thermal vibrations of the atoms in a zinc crystal have larger amplitudes in the direction of the c-axis than in a direction perpendicular to this axis. Somewhat later Zener derived a theoretical formula for the mean square displacement in a direction ψ with the c-axis of a hexagonal crystal like zinc. This formula was immediately put to test in the author's laboratory. The method used was that of the diffuse scattering of x-rays from single large crystals. This method has the great advantage in this type of investigation that the mean displacement can be measured at a given angle of scattering for as many values of ψ as one desires. On the other hand, the powdered crystal method gives the mean displacement at a given angle of scattering for only one value of the angle ψ. We used Cinnamon's method for growing single crystals of zinc with different respective orientations ψ. We found that the root mean square displacements for liquid air and room temperatures are as shown in the table

ψ	100°K	298°K
0°	.103 A	.172 A
90°	.054 A	.093 A

These values are considerably larger than Zener's theoretical values. However, when Brindley and Spiers's anomalous reflection values are corrected for these thermal displacements they give values for the atomic structure factors of zinc which are those required by wave-mechanics when dispersion is taken into account.

The constitution of the borates: W. H. ZACHARIASEN (introduced by A. H. Compton). Through crystal structure determinations of several borates it has become possible to state some of the principles which govern the constitution of this class of substances: (1) Boron is either tetrahedrally surrounded by four oxygen atoms or triangularly by three oxygen atoms. (2) No oxygen atom is bonded to more than two boron atoms. (3) Not more than one oxygen atom is bonded to the same two boron atoms. Furthermore, the experimental work has led to accurate values for the interatomic distances and for the bond angles involved. A criterion can also be given which to some extent enables one to predict whether the coordination number for boron in a given case is three or four. The constitution of borates, particularly with reference to the polyborates, will be discussed on the basis of these principles. It will be shown how the glass-forming tendency of many borates can be explained from their constitution.

The ruling and testing of diffraction gratings: HENRY G. GALE (introduced by A. H. Compton). By greatly reducing friction in the new ruling engine at the Ryerson Physical Laboratory, we have succeeded in making diffraction gratings of very uniform spacing. It is now possible to study the effect of errors introduced automatically and to compare the resulting effects with those predicted by theory. A grating ruled with perfectly uniform spacing, a_0, will give in any order, N, a single sharp image of a monochromatic spectrum

line. If, however, the spacings, instead of being constant, vary sinusoidally with an amplitude a_1, and with a fixed period, false images appear on each side of the parent spectrum line. These false lines are called Rowland ghosts. Professor Rowland showed that the intensities of the parent line and of the 1st, 2nd, 3rd, etc., ghosts may be calculated from the Bessel functions of $(2\pi N \frac{a_1}{a_0})$ of order zero, 1, 2, 3, etc., respectively. The new ruling engine performs so consistently that it has been possible to confirm Rowland's theory experimentally. An experimental comparison has also been made of the relative sensitiveness of knife-edge and interference tests of optical surfaces, and they have been found to be about equally sensitive. Both methods have been applied in testing concave and plane diffraction gratings. Knife-edge tests are very convenient and sensitive for testing the error of run in concave gratings, and interferometer tests are simple and convenient in testing the periodic error in plane gratings. Knife-edge tests may be used to detect departures from straightness in the rulings, when these departures are too minute to affect the definition. In ruling gratings on speculum metal, minute particles of speculum sometimes stick to the diamond point and cause it to fail to rule, often for a good many lines. This difficulty has been overcome for several years by covering the surface with a layer of oil a few millimeters thick. The oil keeps the diamond point washed clear of speculum particles.

Absorption spectra of the rare earths in crystals: SIMON FREED and RAYMOND J. MESIROW (introduced by W. D. Harkins). The absorption spectra of salts of ytterbium (the chloride $YbCl_3 \cdot 6\,H_2O$, the acetate $Yb(C_2H_3O_2)_3 \cdot 4\,H_2O$ and the ethylsulfate $Yb(C_2H_5SO_4)_3 \cdot 9\,H_2O$) were found to resemble those of cerium very closely, especially in their diffuseness even at low temperatures. This is in marked contrast with the sharp spectra of the other rare earths. The resemblance was anticipated on the supposition that the 13 electrons in the 4f shell of Yb^{+++}, one short of the maximum the shell can hold, would give rise to but one term ^2F, the same term as the electron of Ce^{+++} in the same shell gives rise to. That is, activations aside from fine structure are impossible when the 13 electrons remain in the 4f shell. This prohibition is derived from the Pauli exclusion principle as it is applied to gases. The lattice, however, may possibly modify the application of this principle. It was thought likely that the activated states of these ions in crystals would respond to any change in the application of the principle the lattice might impose. The spectra show that the principle holds for these ions in crystals in exactly the same way as it does in gases. Strong confirmation is obtained that the sharp spectra of the other rare earths consist of "forbidden transitions," arising from a change in coupling among the electrons of the 4f shell.

Electronic structures of molecules: ROBERT S. MULLIKEN. Work of the writer on the electronic structures and spectra of molecules is illustrated by some examples. Comparing isoelectronic molecules, analogous energy levels and spectra can be traced, but the energy order and degree of degeneracy of the levels, and the locations of corresponding spectra, vary greatly with the symmetry and the chemical constitution. Among isoelectronic sets which have been studied are: N_2, CO, C_2H_2, HCN; B_2H_6, O_2, C_2H_4, CH_2O; F_2, H_2O_2, NH_2OH, N_2H_4, CH_3OH, CH_3NH_2, C_2H_6; CH_3, NH_3^+, NH_2, H_2O^+, OH; BeF_2, BOF, BO_2^-, NCF, NCO^-, CO_2, N_2O, N_3^+. Another type of comparison is between a molecule and its chemical homologues (*e.g.*, O_2, SO, S_2; or H_2CO, H_2CS); or between a molecule and its chemical derivatives (*e.g.*, C_2H_4, C_2H_3Cl, $C_2H_2Cl_2$, etc.; CH_4, CH_3Cl, CH_3Br, CH_3I, CH_2Cl_2, etc.; H_2CO, Cl_2CO, etc.). By making comparisons of these various kinds, including cross-comparisons, and trying to fit the available data into a (qualitative or partially quantitative) theoretical framework based on quantum mechanics, it has been possible to arrive at rather definite conclusions in many cases as to the natures of the electronic structures, energy levels and spectra, including continuous spectra. The results can be rather well expressed by assigning electron configurations to the various molecules and molecular states, and giving ionization energies for the various types of orbital (*i.e.*, one-electron orbital wave function) which appear in these configurations. Also, comparison of molecular ionization potentials with one another and with related atomic potentials gives information about charge-distribution or polarity in molecules (example, the $p\pi$ potential in I, HI, CH_3I, C_2H_5I, etc.).

(*To be continued*)

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